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Yours very truly

Henry Woodward.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IX.

No. I.—JANUARY, 1902.

THE RETIREMENT OF DR. HENRY WOODWARD.

(WITH A PORTRAIT, PLATE I.)

THE retirement of its Editor from official life, after a period of more than 43 years spent in the public service, is an event which should not be passed over in silence in this Magazine. And during his absence from England the opportunity may be taken to remind both its geological and zoological readers (no one at the present day, we presume, desires to be called a palæontologist) how deeply they are indebted to Dr. Woodward for conducting the GEOLOGICAL MAGAZINE for the long period it has been under his charge as Editor-in-chief. For those who have no regular official duties, which must take precedence of all else, the task of editing a monthly scientific journal, and supplying, when necessary, 'copy' from their own pens to fill gaps, is no light one; but it is one that can be described by no other word than irksome when it has to be performed while running in official harness. Nevertheless, since 1865 the Editor has conscientiously carried on this labour from month to month and from year to year without complaint—and to the satisfaction, we believe, of all his numerous readers. Punctually at the commencement of each month the GEOLOGICAL MAGAZINE makes its appearance; and we trust that it may long continue to do so under the same able editorship.

After its 'coming of age' in 1885, full reference was made in its pages to the Editor's connection with this journal.[1] And it will be unnecessary, therefore, on this occasion to repeat the eulogium then passed by Professor Bonney, except to add that since that date more than fifteen extra years of editorial work have been accomplished. If, as Dr. Bonney said, geologists and zoologists were at that time under a heavy load of debt to Dr. Woodward, their obligations must now be enormously increased.

As some indication of the amount of work, apart from editing this journal, that has been accomplished by Dr. Woodward, it may be mentioned that up to the year 1897 the list of his more important memoirs, papers, and addresses (a few written in conjunction with

[1] GEOL. MAG., 1886, p. 45.

Professor T. R. Jones) totalled 264; by this time they are probably little, if at all, short of 300.

But since on this occasion it is our intention to dwell on Dr. Woodward's connection with the British Museum, rather than with his general work and his editorship of this Magazine, we may pass on to our main subject.

Dr. Woodward first joined the staff of the Museum at Bloomsbury in 1858. The following year he was promoted, and he received a step in 1865 and again in 1867. In June, 1880, on the retirement of Mr. G. R. Waterhouse, he was appointed Keeper of the Department of Geology; and since that date, with his Assistants, he has achieved the task of rearranging the entire Geological Collection in the galleries of the Natural History Museum, Cromwell Road, where, by the aid of popular and well-illustrated guidebooks, diagrams, and descriptive labels, the scientific student, and even the ordinary visitor, can readily derive instruction from the objects displayed in the cases. How much hard work and patience are required for a task of this nature, and what varied kinds of knowledge are necessary in order to bring it to a satisfactory conclusion (or, rather, to keep the Museum up to date), only those who have tried it can judge.

The first edition of the Guidebook to the Geological Department was issued under Dr. Woodward's superintendence in 1881; and since that date each new edition has been expanded and improved. The Guidebook is, of course, for the benefit of the general public, who have, as taxpayers, the first claim on the Museum. But the needs of scientific workers have by no means been neglected, and to Dr. Woodward is due the credit of having initiated in the Geological Department the issue of 'Catalogues' like those which previously proved so valuable to the students of recent zoology. Since 1881 a large number of these Catalogues have appeared under his supervision; how important these are to workers in the life-history of our globe, readers of the GEOLOGICAL MAGAZINE do not require to be informed.

It may be added that, according to the rules of the Civil Service, Dr. Woodward's time of service expired more than four years ago; but, upon the recommendation of the Trustees of the Museum, the Treasury twice sanctioned an extension of his period of service. We learn, moreover, that they have approved of his employment for a year longer on special work connected with the Museum. We also understand that at their meeting on November 23rd the Trustees passed a vote of thanks to Dr. Woodward on his retirement from the office of Keeper for the great services he had rendered during a period of nearly 44 years to the Geological Department.

Readers of this Magazine will, we feel sure, join in wishing Dr. Woodward health and happiness in the comparative rest he has so well earned; and they will be pleased also to have a copy of his portrait, which we have the privilege of inserting.

R. L.

ORIGINAL ARTICLES.

I.—Fossils from the Hindu Khoosh.

By Lieut.-Gen. C. A. McMahon, F.R.S., F.G.S., and W. H. Hudleston, M.A., F.R.S., F.L.S., F.G.S.

Part I.—Fossil Beds and Associated Rocks at Chitral. By General McMahon.

THE fossils described by Mr. Hudleston, F.R.S., in Part II of this paper, were found by Captain B. E. N. Gurdon, C.I.E., D.S.O., Assistant Political Agent, Chitral, on the right bank of the Chitral river, between Chitral and Mastuj. The spot where they were collected is indicated by a small cross marked on the accompanying sketch-map (Fig. 1), which has been based on the map of the Pamirs compiled under the direction of the Right Hon. G. N. (now Lord) Curzon to illustrate a paper by him published in the Journal of R.G.S. of 1890.[1] My son, Major A. H. McMahon, C.S.I., C.I.E., F.G.S., in company with Captain Gurdon, visited Mastuj in October, 1900. He indicates the strata in which the fossils were found as follows:—

"As regards the fossils, they all come from a bed of limestone exposed in a cliff on the right bank of the Chitral river, *immediately* opposite Reshun. Reshun itself is on the left bank of the river, about half-way between Mastuj and Chitral. It is, by the way, the place where Edwards and Fowler made their brilliant defence and were treacherously taken prisoners in 1895.

"This year, after my arrival at Chitral, I made a flying tour of treble marches and more a day, from Chitral to near Mastuj and back, and give you the result of such geological observations as I was able to make. From Dir[2] northwards, I use the names given in Curzon's map.

1. "At Malakand itself there is a broad, nearly vertical dyke, of white granite, about a hundred yards wide, which runs nearly E.N.E.–W.S.W. Between Ashreth and Mirkandi there is a great deal of granite. Owing to the vegetation and surface soil it is hard to tell the direction of the strike. At a point between Ashreth and Mirkandi granite disappears, and I have seen no more traces of it *in situ* northwards in Chitral.

2. "Just before coming to Mirkandi I noticed some conglomerate, and I think there is a bed of it here, but I am not sure owing to vegetation and surface soil. I have marked its probable line of outcrop on the accompanying diagrammatical sketch (Fig. 2, Bed 1).

3. "Close to Mirkandi, on the opposite bank of the river, a bed of red sandstone rock crops out, like the red sandstone near Yasin, described at p. 358, vol. lvi, Q.J.G.S. This runs, as shown in the diagrammatic sketch (Fig. 2), past the back of Kala Drosh (see Fig. 2, Bed 2).

[1] Published as a separate map by Edward Stanford, Charing Cross.

[2] Dir is about nine miles south of the Lowari Pass, marked on sketch-map, Fig. 1.

4. "In the cliff opposite Gairat is exposed a bed of grey limestone which looks exactly like the grey limestone from the Gilgit-Kilik and Gilgit-Darkot series. This bed runs in a clearly defined direction, as shown in Fig. 2, Bed 3. Some of this limestone smells of sulphuretted hydrogen when struck with a hammer.

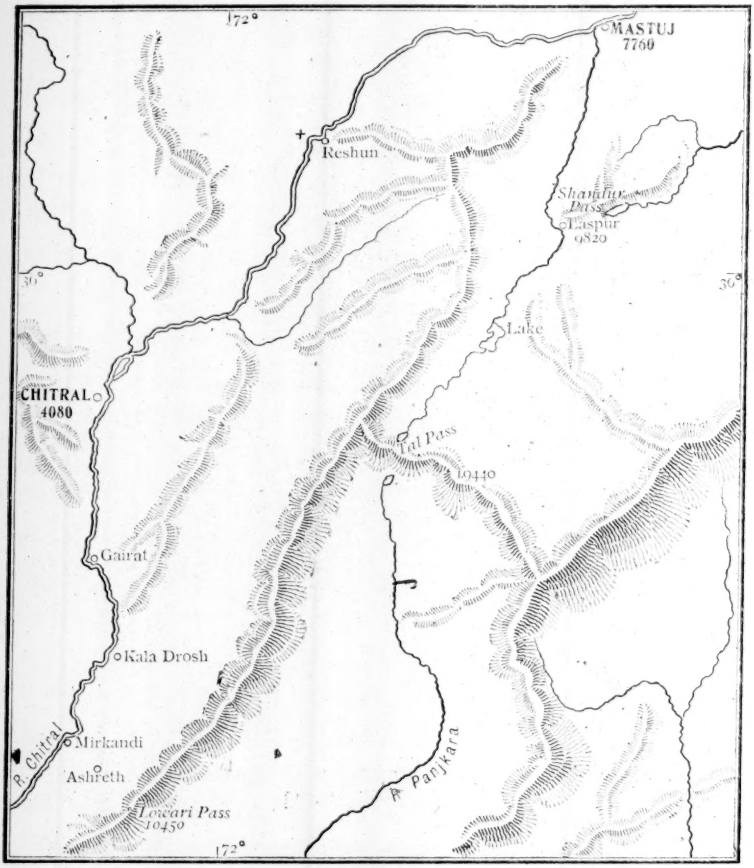

FIG. 1.

5. "Below Reshun a bed of conglomerate crosses the river and runs as shown in the diagrammatical sketch (Fig. 2, Bed 1). The conglomerate is very tough and is traversed by numerous white quartz veins, which pass through the matrix and pebbles, without being diverted from its course by the latter. The pebbles and boulders in the conglomerate are subangular to rounded, and vary much in size and colour.

6. "Just below Reshun, among other beds, one of red sandstone

runs parallel to the conglomerate, and crosses the river, as shown in Fig. 2 (Fig. 2, Bed 2). It is similar to the bed alluded to above.

7. "Opposite Reshun, on the west or right bank of the river, a bed of grey limestone is exposed, which runs parallel to the conglomerate and red sandstone. The fossils found by Captain Gurdon and described in Part II of this paper were taken from this bed of limestone opposite Reshun.

8. "You will see that there are two sets of parallel beds, in ascending order, each set containing a conglomerate, red sandstone, and limestone, as shown roughly in Fig. 2. I am inclined to think that if the beds were followed along their course they would be found to constitute one and the same series, and consequently that there are not two separate sets of parallel beds. Further, I think it not improbable that this group of parallel beds of red sandstone and limestone will be found to be a continuation of those noted by me near Yasin, and again in the Hanza Valley." [1]

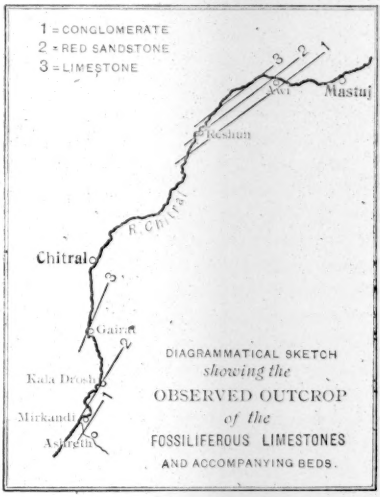

FIG. 2.

In these views I quite concur with my son. There is no evidence of faulting, whilst bending of the strata in the direction of the line of strike is so common in the north-west Himalayas, that this explanation seems to be all that is required to account for the slight divergence in the direction of the strike shown in Fig. 2. The discovery near Chitral of a conglomerate of the character detailed above, associated with a sandstone and a limestone, is interesting to the Himalayan geologist, and it may lead to important results. The triune band described above recalls the Blaini group of the Simla area, which also consists of a peculiar conglomerate, a limestone, and a quartzite;[2] "a band," in the words of Mr. Medlicott,

[1] See paper on Geology of Gilgit, Q.J.G.S., vol. lvi, p. 337.
[2] Medlicott: Memoirs G.S.I., 1865, vol. iii, p. 30.

their discoverer, "that is very peculiar and characteristic, and which can be traced without any doubt to great distances." Mr. Medlicott adds: "This band promises to be of special utility in identifying rocks in the interior, with those of the outer parts of the lower Himalayan region."

The principal members of the group are the conglomerate and the limestone. The conglomerate appears below the limestone[1] in the Simla area, and this sequence is that observed in the Chitral region.

Mr. Medlicott, in his description of the typical Blaini area,[2] notes that "as an irregular accompaniment of these Blaini beds" (namely, the conglomerate and limestone) "I must mention a clear coarse quartzite: at two or three points in the lower course of the Blaini, this bed shows apparently over the limestone." In the Blaini river this "irregular accompaniment" "apparently" occurs above the limestone, but in the Chitral region a red sandstone appears below the limestone. The Chitral red sandstone therefore cannot be a lateral extension of the particular beds seen at Simla; but as Chitral is about 450 miles distant as the bird flies from the Blaini river, it is hardly a matter of surprise that the local conditions of the two places should not have been precisely alike during the Blaini age, and that arenaceous deposits should have been laid down at slightly different horizons at Chitral and Simla.

The red sandstone bed of Chitral, which is associated with a limestone, has been detected in several places in the Gilgit area, and has been described in my paper on that region.[3] As the red colour of this bed naturally strikes the eye of an observer, the bed may prove valuable in leading to the identification of the group of which it is a member in adjoining areas.

My son did not detect the Blaini conglomerate in the Gilgit area, but as his attention had not then been directed to this rock, he thinks it possible that it may hereafter be found in that region. He thought at the time that the conglomerates he came across were probably of glacial origin. It may, moreover, be a work of considerable difficulty to detect the Blaini conglomerate in the Gilgit area, if it occurs there. Gilgit is a region of intense metamorphism, and the conglomerate may there be metamorphosed almost out of recognition. Even in the comparatively unaltered area of Dalhousie, the conglomerate has become schistose and foliated.[4] Moreover, the pebbles imbedded in the matrix of the conglomerate are sometimes locally very sparse; and when this is the case, the difficulty of detecting the rock in a highly metamorphosed area would be greatly increased.

My son's description of the Chitral conglomerate corresponds with the appearance of the Blaini rock in many places in the Simla and Dalhousie districts. The pebbles of the Chitral conglomerate are more or less rounded, and vary much in size and

[1] Medlicott: Memoirs G.S.I., 1865, vol. iii, p. 30. McMahon: Records G.S.I., 1877, vol. x, p. 207.
[2] Loc. cit., p. 31.
[3] Q.J.G.S., vol. lvi, p. 358.
[4] McMahon: Records G.S.I., 1881, vol. xiv, p. 306.

colour. "Many of them," my son writes, "are green, like the green specimens of rocks I sent from the Gilgit district." In my account of the Blaini conglomerate at Dalhousie[1] I note that the white pebbles in the matrix are "of various sizes up to nine inches in diameter. The rock also contains grey and blue quartzite, and quartzite-sandstone pebbles, subangular to rounded, which weather various colours." The matrix of the Dalhousie conglomerate is a hard slaty schistose rock, whilst my son notes that the Chitral rock is too tough and hard to break with a hammer. He also mentions that the matrix of the Chitral rock has an igneous appearance, which has its counterpart in the Blaini rock as seen in eastern Sirmur, where the matrix of the conglomerate resembles a volcanic ash, and the whole rock a volcanic breccia.[2]

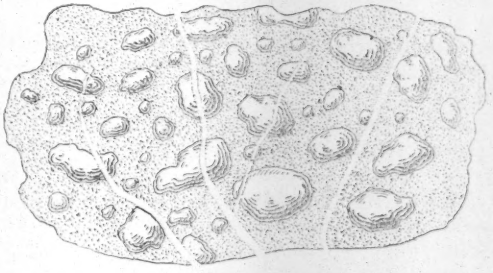

FIG. 3.—Chitral conglomerate with quartz veins.

The circumstance noted above, that the Chitral conglomerate is traversed by quartz veins, which penetrate the matrix and pebbles indifferently, is one that I have often observed in the Simla area. I have within the last few days received from Captain Gurdon, large specimens of the Chitral conglomerate, which were obtained by blasting the rock. (Fig. 3.)

The specimens contain very numerous pebbles, varying greatly in size up to $3\frac{1}{4}$ inches in length; they are mainly subangular, but many are rounded and a few are angular. The matrix is an indurated, fine-grained, slaty grit, or arenaceous mudstone. The pebbles consist of limestones, slates, sandstones, and quartzites, and there are some rounded white quartz pebbles, which recall the 'eggs' of the Simla rock, but are much smaller. The whole rock is deeply impregnated with carbonate of lime, probably due to infiltration from the adjacent limestone.

The Blaini group has a remarkably wide extension. It has been traced to Mussoori,[3] and a conglomerate resembling it has been observed as far east as Manipur.[4] In its westward extension I followed it through a large part of the Chamba State,[5] and it

[1] Loc. cit., p. 306.
[2] Oldham: Man. Geol. India, 2nd ed., p. 132.
[3] Man. Geol. India, 2nd ed., p. 133.
[4] Loc. cit., p. 148.
[5] Records G.S.I., vol. xiv, p. 305; vol. xviii, pp. 35, 79.

was traced by Dr. Hutchison through north-east Chamba into Lahoul.[1] The occurrence of the conglomerate has been noticed by Mr. Lydekker, F.R.S., in numerous places in Kashmir.[2] There is no *primâ facie* improbability, therefore, that representatives of the Blaini series should occur in Chitral and Gilgit. Should subsequent observations confirm my suggestion that the Chitral band of conglomerate, red sandstone, and limestone represents the Blaini series, the fact will be of great importance. The conglomerate and red sandstone are striking rocks, capable of easy recognition, and will afford a definite geological horizon in adjacent areas, where intense metamorphism has obliterated fossil evidence.

The Blaini beds, which in the Simla district are unfossiliferous, were originally regarded as of Upper Silurian age[3] at the suggestion of Dr. Stoliczka, who regarded the Muth beds[4] of Spiti as the equivalents of the Blaini series of Simla. Subsequently the Blaini conglomerate was supposed to represent the Salt Range conglomerate and the Talchir boulder bed, and was considered to be of Carboniferous or Permian age.[5]

The age of the Chitral limestone has now been determined by Mr. Hudleston, on the evidence of well-preserved fossils; and it remains to future observers in the field to work out the important question, whether or not the Chitral band of conglomerate, red sandstone, and limestone truly represents the Blaini group of the Simla area. If it does, as I suggest, Mr. Hudleston's investigations will have the important result, not only of determining the age of the Chitral beds, but of supplying an easily recognizable horizon for the elucidation of a widespread area in the north-west Himalayas.

The Chitral region, I remark in conclusion, is one of the most difficult in the world for detailed geological exploration. The frontier tribes are not to be trusted; the mountains are very lofty; the gorges deep and narrow, and profound precipices are of frequent occurrence.

II.—Moraines and Mud-streams in the Alps.

By Canon T. G. Bonney, D.Sc., LL.D., F.R.S.

IT has often occurred to me during my Alpine wanderings that masses of earthy material containing boulders are too readily identified as moraines. That the latter exist, both here and in other mountain regions, no one would for a moment dispute, but deposits, sometimes very closely resembling till, may be produced in other ways. One is by a bergfall. The result of this in some cases, as at Goldau, Plurs, near San Vito (Ampezzo road), or the Col de Cheville, can be easily recognized; but when the fallen material consists largely

[1] Loc. cit., vol. xviii, p. 90.
[2] Memoirs G.S.I., vol. xxii; Records G.S.I., vols. ix, xi–xv.
[3] Oldham: Man. Geol. India, 2nd ed., p. 137. Records G.S.I., vol. xiv, p. 307.
[4] A red quartz conglomerate is a prominent member of the Muth series. Memoirs G.S.I., vol. v, p. 22.
[5] Man. Geol. India, p. 137; Memoirs G.S.I., vol. xxiii, p. 54.

of shale and friable rock, when there is a certain admixture of boulders from a distance (formerly perched blocks), its origin is not so readily determined. The enormous mass of débris on the north bank of the Rheinthal, between Chur and Ilanz—a mass which extends from Digg, through Flims, to rather beyond Laax, consisting of earthy stuff, probably mainly smashed shale or slate, and of boulders, apparently limestone—is regarded as bergfall by the Swiss geologists, and yet any section in it might readily be taken for moraine. Even more moraine-like in general aspect are the singular mounds of débris in the valley of the Rhone near Sierre. These consist of a clayey material full of small rock fragments, angular and subangular, which are generally less than an inch in diameter, and seldom exceed four or five inches, though now and then a large boulder occurs. Of these fragments the majority are dark limestone, sometimes slaty; a small proportion, generally more water-worn, being gneiss or schist. These mounds are regarded as the relics of a great bergfall, but were it not for the paucity of crystalline rock, especially among the boulders, they might well be passed as moraines, for their relation to the slope down which the material has descended is not obvious at a glance.

The débris deposited by flooded torrents often closely resembles moraine. I may quote a few instances from my own experience. At Zinal in July, 1895, we heard, late one evening, an extraordinary roaring noise, which proved to be caused by the descent of a mass of grit and boulders mingled with water, which had issued from a glen on the eastern flank of the valley.[1] This formed a great fan of débris (not very unlike moraine, except perhaps subangular fragments were commoner), which had flowed down to the river. I once actually watched a similar occurrence, the result of a violent rainstorm, at Les Ouches, near Chamonix. Thousands of cubic feet of black liquid mud and broken shale or slate came sweeping down a gully and buried the high road for some distance. I passed over another discharge of flood débris in the Zillerthal a few days after it had descended. Here the valley was rather broad, the carriage-road running along it near the lowest part. The discharge, which had been caused by a local 'cloud-burst,' had come from the mountain slopes on the left bank and had followed the path of two small streams. The first had affected the larger area, having buried everything—road, gardens, fields, thickets—under a mass of débris, a mixture of mud and rock fragments, small and large. There were hundreds, nay, thousands of blocks, in shape and size like portmanteaux. A wooden chalet had been torn up and swept along like an empty packing-case for about 200 yards. Here, though no doubt could arise as to the nature of the deposit, the material itself was not very unlike a moraine of the lowlands. Again, the road and the railway in the Rhone Valley near Monthey cut through an enormous mass of material, which might easily be taken for moraine, as it is a mixture of mud and rock fragments of various

[1] I was informed that the stream, some two or three thousand feet above Zinal, had been dammed by a slight landslip till the ponded-back water burst the barrier.

size, some being nearly a hundred cubic yards in volume. This, which descended in August, 1835,[1] after unusually heavy rains, appears to have been started by the fall of a large mass from the crags of the Dent du Midi, which was augmented on its course by snow and rock débris, and rendered more liquid by swollen torrents, till it descended to the Rhone like a stream of lava. These instances may suffice, though it would be easy to add to their number.[2]

Mud avalanches and fans of débris are on a grander scale in the mountains of Hindustan. Sir Martin Conway mentions them in his well-known book "Climbing in the Himalayas." For instance (p. 127), the valley of the Indus near Bunji is broad and flat-bottomed; on the western side "is a mighty wall of rock, on the eastern it is bordered by steep slopes." The slopes and the wall, he thinks, cannot meet at a less depth than 500 feet below the bed of the valley, and not improbably at one much greater. "By what processes were these vast débris accumulations brought together? The problem is of general interest, for the Bunji valley may be regarded as typical of Central Asian valleys generally, and what is true of it is true also of the Pamir valleys and of those in the regions of Western Tibet and Eastern Turkestan. . . . . It is clear that the valleys have not been filled by the agency of bursting lakes. The gentle dip of the bedding of the débris towards the river proves that the stuff came from the side slopes. . . . . The question arises, How was such a quantity formed and caused to descend? Here the reader must bear in mind the nature of the climate in the regions under consideration; it possesses two main qualities, extraordinary dryness and extreme and rapid variation of temperature. The rainfall is trifling over the whole area, except where the mountains reach great altitudes, and there snow is precipitated in considerable quantity. . . . . Throughout all the region there is constantly being provided a mass of loosened débris such as is never found in the better known mountains of Europe." The low slope of this valley deposit, sometimes barely 3°, and the large area covered, he goes on to say, prevent us from referring it to ordinary bergfall, and makes 'mud avalanches' the only possible explanation. These have been seen actually descending by various travellers—Colonel Godwin-Austen, Sir William Lockhart, Dr. and Mrs. Bullock Workman; indeed, the last named had a rather narrow escape from one.[3] Sir Martin Conway himself saw two come down a gully near the Hispar glacier, one just before, the other just after his party crossed it.[4] "It was a horrid sight. The weight of the mud rolled masses of rock down the gully, turning them over and over like so many pebbles, and they dammed back the muddy torrent and kept it moving slowly but with accumulating volume. Each of the big rocks that formed the vanguard of this avalanche

[1] A summary of the facts will be found in Joanne, "Itinéraire de la Suisse," Route 25 (between St. Maurice and E'vionnaz).

[2] See also Dr. A. Irving, Quart. Journ. Geol. Soc., vol. xliv (1888), p. 158.

[3] "In the Ice World of Himalaya," p. 156.

[4] "Climbing in the Himalayas," p. 323.

weighed many tons; the largest were about ten-foot cubes. The stuff that followed them filled the *nala* to a width of about forty and a depth of about fifteen feet. The thing moved down at a rate of perhaps seven miles an hour. . . . . Looking up the *nala*, we saw the sides of it constantly falling in and their ruins carried down." Finally, the material spread out as a fan on the bed of the valley below.[1] Earth pillars, he observes, are frequently seen to be carved from the older masses.

Thus it is evident that under certain circumstances deposits, which may be termed mud avalanches, do not a little towards filling up the valleys in mountain countries. Such deposits are, I believe, more common in the Alps than is sometimes supposed. In my diary for 1893 I made this note on the valley between Hinterrhein and Splugen:—"A marked feature is the quantity of débris brought down by the lateral torrents, forming alluvial fans cut through by the main river. The stuff is often like moraine, but the stones (ranging from sub-rotund to angular) are more rounded, and there is a considerable quantity of earthy matter, often more than the stones. The deposit exhibits a slight stratification, and reminded me at times of the esker material which I had seen near Parsonstown."[2] It is clear that under certain circumstances this method of accumulation of débris in valleys is most important, and, where not closely studied, might be mistaken for till. Below Andeer, where the valley again opens out, great fans of débris are seen on the left bank, similar to those described above, exhibiting in places fairly marked stratification. The river has exposed a fine section of one on that bank, the cliff being perhaps fifty feet high, and on the opposite side, where the valley is contracting, is another. As the drift can be traced down to the level of the river, the valley must have been excavated to its present level before these fans were deposited. But it is often extremely difficult, when only an isolated section can be obtained, to say whether this is in a mud avalanche or a true moraine.[3]

From these I pass to deposits which have been often claimed as moraines, such as that from which the earth pillars at Useigne, in the Eringerthal, have been sculptured. Very near to these the main valley is joined by the Val d'Hérémence. The deposit, a kind of till in which large boulders are not very numerous, extends some distance into the latter and for more than two miles up the former, occurring first mainly on the left bank, then on the right.[4] Good sections may be frequently seen. In one case, on

[1] See also "The Making of a Frontier," by Colonel A. Durand, pp. 33, 34. (As I have explained in a paper now in the hands of the Geological Society, I think Sir M. Conway's description includes with the mud avalanches a breccia which has a rather different history.)

[2] I had examined this during the previous Summer (1892).

[3] In my diary I have given the facts which make for the one or the other conclusion, but as there is no impossibility that both may occur in this valley I deem it needless to enter into particulars.

[4] It is shown clearly on the Geological Map, where it is marked as "Terrain Glaciaire." The material, from which the actual pillars are carved, is perhaps more directly in the line of the Val d'Hérémence.

the right bank, where there are imperfect pillars, the material seems to be connected with a wide tributary opening, rock appearing opposite to it on the left bank of the river. In the neighbourhood of the pillars (about half a mile below Useigne) the material certainly shows some stratification rudely parallel with the slope of the hill, as in a talus. "It is morainic, not moraine—hillside talus, mud, torrent débris, moraine, perched blocks, all sorts of stuff brought down by rain and stream. It looks as if the valley, after having been excavated to something like its present depth, had been choked up with this mixture."[1] The way in which it is distributed, not in mounds, but forming parts of the slopes descending from either side of the valley, shows that it cannot be true moraine.

The earth pillars near Stalden have a similar origin. These occur on the right bank of the Vispthal, roughly opposite to the steep ascent on the railway before it reaches that village. I came to the conclusion, more than twenty-five years ago, that this material had descended from above, and have been confirmed in it by later study, especially during the past Summer. The pillars have been carved out of a pale grey 'earth,' more or less micaceous, containing some small fragments (but less numerous than in a moraine) with occasional boulders (crystalline rock), now and then large. The annexed diagram, rough though it is, will save a long description.

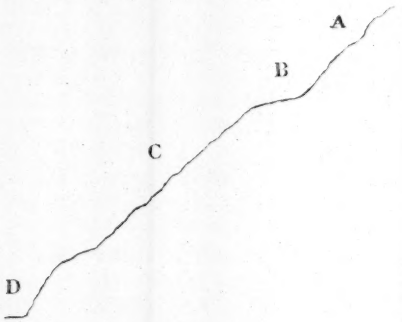

FIG. 1.—SECTION RIGHT BANK OF VISP NEAR STALDEN.

A, mountain side, steep and rather bare, rising for some hundreds of feet and forming the skyline; B, cultivated ground, forming a kind of shelving terrace; C, long slope, with rock showing in the steeper part, on which streamlets (sometimes dry) have cut ravines, on the flanks of which are pillars; D, cliffs above the Visp.

The terrace bank, thus furrowed, extends for some hundreds of yards, and bears no resemblance in form to a moraine either lateral or terminal. But it is not the only instance. Part of Stalden stands on a mound of similar material, through which the railway cuts just before entering the station. At first sight this more

[1] Note written on the spot in 1900, when I saw them again after an interval of twenty-four years.

nearly resembles a moraine in outline, but we find on further examination that it extends some distance up the valley beyond the village, not to mention other difficulties. We have not, however, far to go to obtain much stronger evidence. The lower part of the mountain buttress between the Gorner and the Saas Visp is formed of, or more strictly speaking masked by, identical material, which also has clearly come from above. Looking up the latter valley from the station at Stalden we can see on its right bank, at some distance, another terrace slope of the grey débris, lodged in similar position to that with the pillars. In fact, as we walk up the valley to Saas, we pass by two or three of these deposits; that of which I give a rough diagram being on the left bank, not far from the Boden Brücke. This affords us distinct proof that the débris was

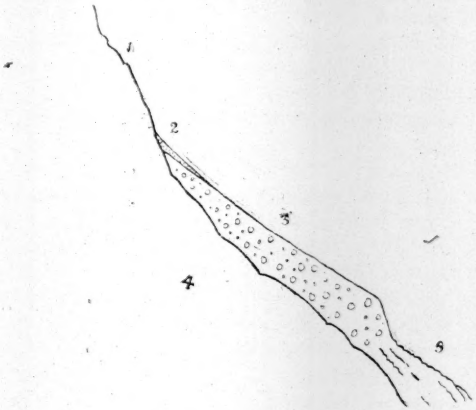

FIG. 2.—SECTION BY THE SAAS VISP NEAR BODEN BRÜCKE.

A diagram constructed from a sketch taken on the mule-track.

(1) Bare rocky crags (gneiss) rising up to the skyline.
(2) Talus of fallen rock.
(3) 'Mud avalanche' material.
(4) Steep bare rock, rounded, smoothed and scored by ice. This, near where I stood, could be traced to within 10 feet of the Visp.
(5) Talus at foot of cliff-face of mud avalanche, overgrown by vegetation descending towards the Visp—which would be nearly an inch below the bottom of the drawing.

deposited after the ice had finally retreated from this part of the valley, that it descended from some part of the mountain above the cliffs which we see from below, and that it was formed under conditions which no longer exist, for its upper part is now buried by a talus of broken rock derived apparently from these cliffs.[1] In no instance is the rock which has supplied the avalanche material

[1] I have little doubt that the Zwerglithurm near the path from Viesch to Eggischorn, figured by Sir C. Lyell ("Principles of Geology," ch. xv), which I examined in 1881, has been carved out of similar material.

visible from the valley, since the upper parts of the mountain are concealed hereabouts by their lower buttresses. But occasional glimpses are obtained of a mass of pale-coloured schists, which no doubt extends for a considerable distance, and is perhaps identical with one which I remember to have seen near the entrance of the Vispthal.

The earth pillars of the Katzenbach and the Finsterbach have long been famous. These are in upland valleys, high above that of the Adige, on the flanks of the Rittnerhorn. As they have been so frequently described, a few words about the material will be sufficient. The matrix is a red earth, which becomes hard in drying, and has probably been supplied by the destruction of the well-known 'porphyry.' Most of the smaller stones are more or less rounded, even the big blocks (up to 50 or 60 cubic feet) being not unfrequently subangular. Stones of any conspicuous size are not very numerous; it would not be difficult to find a cubic foot of material without one bigger than a marble. Once or twice I saw signs of stratification, and the larger boulders seemed often to occur in layers. The relation of these masses of débris to the slopes on either side and to the upper part of the mountain itself satisfied me that the ridges and pillars had not been carved out of mounds, but from material which had been deposited so as to partly fill up a valley already excavated in the 'porphyry.' On my first visit I came to the conclusion, with which my companion, the late Mr. W. Mathews, agreed, and which was strengthened on a second examination nine years afterwards, that this material, though very likely incorporating moraine stuff, was not true moraine, but had descended into the glens from above, and thus was more or less of the nature of mud avalanche.

Though these deposits of muddy débris often are not easily distinguished from true moraines, the question may occasionally be settled at once by the correspondence between the materials and those *in sitû* on the mountain side above; but as these slips (so far as I know) are always later than the final retreat of the ice, they may have carried down with them and incorporated moraine and perched blocks. As a rule, however, in one of these deposits, the finer material bears a larger ratio to the boulders than is usual in true moraines under similar conditions. In them, as far as my observations go, this ratio increases with the distance from the head of the valley. But the material in three, at least, of the districts named above—in the Eringerthal, in the Vispthal, and in the upland valleys on the Rittnerhorn—resembles what we should expect to find in moraines on subalpine or even lowland regions. The form, however, is a more characteristic feature. A moraine in its natural condition is more or less of a mound. These flood deposits either shelve gently up—like all slopes of débris—to the cliffs and glens down which they have descended, or fill up the bed of the main valley to a considerable depth.[1] The latter any ordinary terminal

[1] As is the case with the trass which still remains in places in the Brohlthal (Eifel).

moraine could not do, for if, instead of forming a mound, it trailed along after the retreating ice, it would be comparatively thin. Some glacialists, however, may claim the deposit for ground moraine, which once loomed very large in not a few imaginations, and was defined as "rock rubbish derived from the subjacent rock masses by the ice itself." Such material no doubt exists, but to what extent (as I have repeatedly urged) must be determined by proof, not by hypothesis. Spitzbergen and Greenland were then generally supposed to bear some resemblance to the condition of the Alps in the Great Ice Age. But the researches of Professors Gregory and Garwood in the former, and of Professor Chamberlin with other American observers in the latter, have not been rewarded by the discovery of enormous masses of indubitable ground moraine, exactly resembling the Boulder-clay of Britain and North Germany. Material to which the former term may be applied seems to be produced in one of three ways: (1) in certain cases an advancing glacier pushes before it, more or less levels down, and finally travels, as if along a terrace, over what began as terminal moraine; (2) when a glacier ends in an ice-cliff, fragments from the upper parts of this and rock débris from the top may fall down, become frozen together, and then adhere to the lower part of the advancing mass, by which they are carried down the valley and finally deposited on its rocky floor, when the ice melts away; (3) either this material, or any picked up locally by the glacier as it is moving downwards, may be sometimes distributed by differential movements of the ice in a more or less stratified manner through its lower portion. This approaches nearest to the old ideal of ground moraine; but as that stratification rarely extends for more than a hundred feet from the bottom of the glacier, the material which it has left cannot be very thick.[1] But as an ice-sheet, when moving over nearly level ground, seems not only to be incompetent to erode but even to override loose material, already deposited, one layer, in case of a second advance, might be superposed on another. In the Alps, however, a retreat of the ice is generally signalized in the lower regions by a deposit of stratified gravel, while in the upper the glaciers were obviously able to keep their rock beds tolerably clean. We cannot, therefore, in my opinion, apply this explanation to the deposits under discussion. Morainic—that is, partly composed of ice-deposited material—they may be,[2] but they are not true moraines.

The Alps accordingly appear to have passed through a phase of denudation which is still in process in the Himalayas. In the former, when the snow and ice first disappeared from the zones which are now uncovered for most of the year, the rock would be not only rather thickly sprinkled with morainic débris, but also

[1] So far as I can judge from the excellent illustrations to the papers mentioned above, the débris can hardly amount to one-fifth of the whole mass, so that the former is seldom likely to exceed 20 feet, and would generally be much less.

[2] This, if I mistake not, is included by Continental writers in the term 'Glacial Schotter.'

often without protection from talus-slope or vegetation. It would therefore be more readily affected by changes of temperature, heavy rainfall, and an inclement climate, and thus avalanches or torrents of mud would be on a larger scale than now. As a rather dry climate, according to Sir Martin Conway, is also distinctly favourable to this kind of denudation, it may have been very active in the 'Steppe Age' which probably closed the Glacial Period. But of this we perhaps hardly know enough to do more than venture a suggestion.

III.—The Origin and Progress of the Modern Theory of the Antiquity of Man.

By Sir Henry H. Howorth, K.C.I.E., F.R.S., F.G.S., F.S.A.

WHEN Dr. Woodward asked me a few months ago to review some pamphlets on early Man and his remains, I very reluctantly promised to do so, because I felt that if I were to be frank and sincere I must speak of some recent developments of the study in unsympathetic terms, which would not be welcome in some quarters. I little expected, however, that I should have been overwhelmed by such a shower of peppercorns as I find on my return from Italy was the case in the September number of the Geological Magazine.

If he thinks the subject worth ventilating and sufficiently interesting, Dr. Woodward will perhaps afford me some space in which to deal with my critics, more especially as the issue continues to be, what Haeckel lately called it, the problem of problems. I also wish to correct one or two slips which I made in consequence of having to write so hurriedly before.

My purpose is not so much criticism as to try and disentangle the story of the growth of rational views in regard to the origin of man and to define where the problem now stands. I must deal, therefore, in rather more detail than has hitherto been done with the history of the controversy.

The first rational statement on the question known to me was the famous verse of Lucretius—

> "Arma antiqua, manus, ungues, dentesque fuerunt,
> Et lapides, et item sylvarum fragmina rami.
> Posterius ferri vis est, aerisque reperta;
> Sed prior aeris erat, quam ferri cognitus usus." [1]

This extraordinary statement (considering when it was written) took a long time to fructify. The first actual fact recorded, so far as I know, in support of it, viz. the discovery of the Palæolithic implement found in Grays Inn Lane, was not published until the beginning of the eighteenth century. I gave details about it in my previous paper. The interest of this stone, however, like that of the Cannstadt jawbone found in the loess in 1700, is rather retrospective

[1] "Ancient arms were hands, nails, teeth, and stones and also broken branches of trees. Afterwards the virtue of iron and of bronze was discovered, but the use of bronze preceded that of iron."

than direct. The importance of the discovery in each case was only appreciated and its real lesson learnt at a much later time.

Eckhard, Professor of History at Brunswick, who died in 1730, in his work "De Origine Germanorum," which was not published until twenty years after his death, says, "Lapides armis apud omnes successere aerea" (i.e. "bronze everywhere succeeded stones for arms," op. cit., xlii, p. 81); Borlase, in his "Antiquities of Cornwall," 1753, argued in favour of the three ages of man; while Goguet, in 1758, in his "L'Origine des lois, des arts, et des sciences" (vol. i, book ii, ch. 4, p. 133), says, "All antiquity is agreed that there was a time when the use of metals was unknown in the world." These statements, however, were only echoes of Lucretius.

The first person who argued scientifically that men at one time used stone for their weapons and tools to the exclusion of metal, that is, argued in favour of a Stone Age, was, according to M. Le Hon, Mahud El, who, having examined a considerable number of so-called thunder-stones, i.e. stone axes, urged in 1734 that they were the first instruments made by man at a period when he did not know metal ("L'Homme Fossile," p. 23). Frere, who wrote a good deal later, i.e. in 1797, based his conclusion on certain implements which he had found in the Suffolk gravels. To show how well he had grasped the general conditions of this particular point, I will quote an additional paragraph to that referred to in the previous memoir and cited from his paper in the thirteenth volume of *Archæologia*, p. 103. He says: "The implements lay in great numbers at the depth of about 12 feet in a stratified soil, which was dug for the purpose of raising clay for bricks"; and he concludes: "The situation in which these weapons are found may tempt us to refer them to a very remote period indeed, even beyond that of the present world; but whatever our conjectures on that head may be it will be difficult to account for the stratum in which they lie being covered by another stratum . . . . The manner in which they lie would lead to the persuasion that it was a place of their manufacture, and not of their accidental deposit, and the number of them was so great that the man who carried on the brickwork told me that before he was aware of their being objects of curiosity he had emptied baskets full of them into the ruts of the adjoining road. He concludes that the different strata were laid down by different inundations." So much for Frere.

It was the explorers of caves, however, who first produced evidence that man had existed in Europe when hyænas and lions were still living there; thus, in 1774 Esper, in publishing his account of the cave at Gailenreuth, tells us he had found a jaw and a shoulder-blade of a man mixed with the remains of these animals, and he declared it to be his opinion that these bones were all contemporary. There is no reason to question either Esper's competence as a witness or the fact of the discovery. In 1804 Rosenmuller published an account of his own researches in the same district, and says that he was convinced by the testimony of

his own eyes that the bones of men had undoubtedly been found mixed with those of bears and lions in the caves of Gailenreuth. In the year 1700 some extensive excavations were made at Cannstadt in Würtemberg, and a vast number of remains of so-called Pleistocene beasts were found more than a century later. These bones were examined, and a human jaw and some other human remains were found among them. Cuvier, in referring to them in the first edition of his Oss. Foss. in 1812, refused, however, to consider the bones as contemporary.

In the introduction to his "Petrefactenkunden," published in 1820, Schlotheim, who explored the caves at Gailenreuth more minutely, described how in the fissures in the gypsum quarries at Köstritz in Germany human bones had undoubtedly been found with the bones of *Rhinoceros antiquus*, an extinct horse, the great extinct stag, and the fossil hyæna and lion. "Human bones had been recognized there," he tells us, "since the first opening of the quarries thirty years before, and in almost every gypsum quarry in the district." The various bones were found together, assembled in a heap. He argues that these bones could not have come there by way of burial or adventitious falls into the fissures, nor by other accidental causes, but were always found with the other animal remains in the same relations, and *they appeared to be strictly fossil and to have been swept thither by floods, with the other animal bones, at the period of the formation of the alluvial bed itself.* If this view be confirmed, says our author, it will render probable the supposition that the human bones found in calcareous tufa are likewise referable to the same period, and *consequently that man existed here previous to the formation of the alluvial beds, the last great revolution to which the earth has been subjected.*

In the *Nachtrage* to the same work published in 1822, Schlotheim describes further researches in the same place, and speaking of the human bones which were in his collection from there, he says: "They betray a great antiquity, although they have not all undergone a change in an equal manner. Some of them have lost their animal gluten and are even penetrated with gypsum, as is the case with a considerable portion of the other animal bones, while others are only slightly calcined and decomposed. This varying condition of the bones is likewise observable in all the fossil bones of Köstritz."

Schlotheim tells us further that some human bones in his collection were found 26 feet below the surface, and underneath two phalanges of a rhinoceros, quite fossilized, which lay 8 feet above them,[1] and he urges that it is quite evident that in the country near Köstritz human bones are found intermingled, without order, with the bones

[1] These bones, according to a statement by Mr. Carter Blake, are now or ought to be in the British Museum. However this may be, I am safe in stating that there is a fine series of Gailenreuth and Scharzfeldt cave-remains in the Geological Department of the Natural History Museum, Cromwell Road, formed by the Earl of Enniskillen and Sir Philip de Malpas Grey Egerton in the early part of the last century.

of animals of the ancient world and with those of existing species, and under precisely the same circumstances, being firmly enveloped and compacted in the loamy deposit which occupies the fissures and cavities of the bed of gypsum that occurs in that vicinity. "It is undeniable," he says, "that in Winter's gypsum quarry human bones were discovered at the depth of 26 feet from the surface, lying 8 feet below the bones of the rhinoceros also there deposited. The human bones, like those of the other animals, are more or less altered, and deprived of their animal gluten. Human bones and skeletons have also been found in other places within the tract of the alluvial formations, in the vicinity of the repositories of large land animals of the ancient world, but which have not hitherto received that attention which they deserve. All these conclusions give, on the first view, probability to the conclusion that the other animals were destroyed at the same time as man, and, consequently, that the latter was already in existence in this country at the period of the destruction of the large animals; an opinion which I have already advanced."

This is all very plain, very explicit and precise, and represents the view now universally accepted, and Schlotheim ought to be considered as its first scientific champion. He would perhaps have been so regarded had he not been dominated by *a priori* views, which were then natural, and which made him suggest as *a possibility* that the human bones may have been brought thither by floods at a later time than the animal bones, and this in the face of the fact that the deposits in these caves of Gailenreuth were cased in with stalagmite and did not contain secondary burials. He therefore adopts a position of hesitation. He concludes, however, with the words: "So much, however, appears to be proved, that they [i.e. the human bones] occur here in a fossil state, having been brought hither by great floods at very remote times."

The memoir by Schlotheim came into the hands of Mr. Thomas Weaver, who in 1823 published a translation of it with notes in the *Annals of Philosophy*, vol. xxi, § 17. In these notes Weaver argues very acutely against the bones of men and those of the ancient animals at Gailenreuth having been deposited at different times, and claims that they were all laid down together by the same diluvial movement, and were therefore contemporary. He also shows that Schlotheim's doubts as to the contemporaneity of the ancient and more recent animals whose bones were found together, are answered by the fact that Buckland found precisely the same varying conditions in the bones from Kirkdale Cave. This shows that both in Germany and in England very sane and sound views on the antiquity of man, views which are now general, had been championed on perfectly scientific grounds as early as 1823. The position would then probably have been finally won had it not been for the authority of Cuvier and Buckland, who were strongly prejudiced against the view that man was contemporary with the extinct beasts. The former was against the occurrence even of fossil monkeys. In 1823 a very distinguished and competent

Austrian geologist, Ami Boué, discovered some bones comprising half a skeleton, but no skull, in the loess at the little town of Lahr, two German miles from the Rhine, almost opposite Strasburg in Baden. Speaking of the loess there and of this discovery, we are told: "Ce dépôt renferme des os d'espèces perdues, et c'est lui qu'une fouille avait entamé. Des ossements étaient placés à différentes hauteurs et dans des lieux où rien n'indique qu'il y ait eu jadis un cimetière. D'ailleurs les os étaient tellement engagés dans la roche qu'il fallut prendre assez de peine pour les dégager; l'auteur fut obligé d'en laisser qui étaient situés trop avant dans la marne, tandis que cette dernière ne paraissait nullement avoir été remaniée et offrait en outre quelques coquilles terrestres d'eau douce." (Matériaux, etc., xviii, 29, 30.)

Boué, who was convinced that human bones could not exist under such conditions, and thought they must belong to some animal like man, sent the bones to Cuvier, and was greatly surprised when Cuvier pronounced them to be human. In 1829 M. Boué revisited the place where he had made his discovery, and confirmed his former observations, but in view of Cuvier's determined scepticism he suggested the possibility that, although the bones had not been artificially buried by man, they might have been washed to the place where they occurred, together with their matrix, in some exceptional flood of the Schutter or Rhine. In reporting these facts he further mentions that Count Razumofski had discovered some human skulls mixed with the remains of extinct animals in the deposit covering the Magnesian Limestone near Baden in Lower Austria. This last discovery has a more important meaning, of course, than it had in 1829, when the antiquity of man was still in question (see Ann. Sci. Nat., vol. xviii, partie Bibliographique, 150, 151).[1]

Lyell tells us that the collection of Lahr bones found by Boué was left in Cuvier's care, and having been neglected was lost ("Antiquity of Man," 4th ed., 244). Boué maintained his views in spite of Cuvier's scepticism, and many years afterwards, namely, in 1852, communicated to the Berlin Academy a short paper embodying his previous researches, in which he reiterates that the bones had not been artificially buried, and says: "*Ich noch jetzt damals glauben muss dass diesen Knochen wie die Schnecken-Gehäuse gleichzeitig mit dem mergeligen Löss-Gebilde und selbst in seinen untern Schichten abgesetzt wurden*" (Sitzberichte, vol. viii, p. 89).

In the same year that Boué made his discovery, i.e. in 1823, Professor Crahay read a paper before the Maestricht Academy on a human lower jaw still preserved at Leyden, which was found 19 feet below the surface, where the loess joins the gravel and is overlain by intact and undisturbed pebbly and sandy beds. Large numbers of remains of extinct animals were found apparently at the

[1] In my previous paper I carelessly gave a wrong reference for these facts, about which my friend Professor Rupert Jones is rightly sarcastic, and which I have now corrected. The reference is, however, a difficult one, and the "partie Bibliographique" was published separately, and has a distinct pagination.

same horizon, some of the Mammoths' remains being at a higher level. M. Crahay's paper was first published in 1836 in the Bull. de l'Acad. Royale de Belgique, vol. iii, p. 43. Lyell, who verified the facts, regarded this as one of the first examples of the occurrence of remains of man and extinct animals in a Pleistocene alluvial deposit in the open plains ("Antiquity of Man," p. 241).

Let us now turn to England. On the subject of caves and their contents Buckland's opinion dominated Englishmen just as Cuvier's dominated the Continent, and naturally, for he had had great experience in excavating caverns. He took the same side as Cuvier in regard to the introduction of remains of man into the caves having been later than those of the extinct animals. In his "Reliquiæ Diluvianæ," 1824, he mentions the discovery of human bones encrusted with stalactite in a cave in the Mountain Limestone at Burrington in the Mendips, mentioned in Collinson's History of Somerset. The mouth of the cave was nearly closed by stalactite, and many of the bones were encrusted with it. In the case of the skull the inside as well as the outside was encrusted with it, "and I have," says Buckland, "a fragment from the inside which bears in relief casts of the channel of the veins along the interior of the skull. The state of these bones affords indications of very high antiquity." It seems from our present knowledge almost certain that these bones belonged to Palæolithic man.

Secondly. In the cave at Wookey Hole human bones were found by Mr. Miller of Bristol and examined by Buckland in 1823. He says the teeth and fragments of bone were dispersed through reddish mud and clay, and some of them were united to it by stalagmite into a firm osseous breccia. As Buckland, however, found a small piece of a sepulchral urn among the bones, it makes this case a doubtful one. A more important discovery was that made in the cave at Paviland, near Swansea. He tells us how he discovered beneath six inches of earth nearly the entire left side of a human female skeleton, the parts being in juxtaposition, and in the middle of the bones was a small quantity of a yellow substance like adipocere. The bones were all stained with a dark brick-red colour, and enveloped by a coating of ruddle. Near the skeleton were two handfuls of small shells of *Nerita littoralis*, much decayed, and in contact with the ribs were forty or fifty fragments of small ivory rods, nearly cylindrical, and varying in diameter from a quarter to three-quarters of an inch, and from one to four inches in length. Their external surface was smooth in the few which were least decayed, but the greater number had undergone the same degree of decomposition as the large fragments of Mammoths' tusks. He had previously described the discovery of two decayed Mammoths' tusks in the cave. Most of the fragments were also split transversely by recent fracture in digging them out, so that there are no means of knowing what was their original length, as none were found with both extremities intact. Many of them, again, were split longitudinally by the separation of their laminæ, which were evidently the laminæ of the large tusk, from a portion of

which they had been made. The surfaces exposed by this splitting, as well as the outer circumference where it was smooth, were covered with small clusters of minute and extremely delicate dendrites; so also was the circumference of some small fragments of rings made of the same ivory, and found with the rods, being nearly of the size and shape of segments of a small teacup handle. The rings, when complete, were four or five inches in diameter. The rings, rods, and shells lay in the same red substance that enveloped the bones, and were stained superficially with it, and had evidently been buried at the same time as the woman. In another place were found three fragments of the same ivory, which had been cut into unmeaning forms by a rough-edged instrument, probably a coarse knife, the marks of which remained on all their surfaces. "One of these fragments was nearly of the shape and size of a human tongue, and its surface was smooth as if it had been applied to some use in which it became polished; its surface was also covered with dendrites like that of the rods; there was found also a rude instrument resembling a short skewer or chopstick, and made of the metacarpal bone of a wolf, sharp, and flattened to an edge at one end, and terminated at the other by the natural rounded condyle of the bone. . . . No metallic instruments have as yet been found with these remains. . . . The ivory rods and rings and tongue-shaped fragment were certainly made from the antediluvian tusks that lay in the same cave, and must have been cut from the ivory when hard and not crumbling to pieces, as it is at present on the slightest touch, whence we may assume their high antiquity."

We can hardly doubt with our present knowledge that these bones were those of a Palæolithic woman, and it seems a real pity that our famous Dean, whose acuteness was so remarkable, should have been entirely blinded by his prepossessions in favour of a quite impossible and quite unattested Biblical chronology in arguing, as he did, that the bones, etc., had been buried subsequently to the burial of the bones of the extinct beasts, for this discovery ought to have secured for England what was much later secured for Belgium by Schmerling —the honour of the settlement of one great question in the issue, the historical development of which we are tracing, namely, the contemporaneity of man and the extinct beasts.

Let us now turn to France. In a letter written on the 25th of October, 1828, on the caverns of Bize, Tournal tells that he had found in the same strata human bones and those of extinct species with the same physical and chemical features, "jouissant tous deux des mêmes caractères physiques et chimiques. Ces observations peuvent faire mettre en question l'existence de l'homme à l'état fossile." And he continues: "The generally admitted proposition, therefore, that on our actual continents there do not occur human fossil bones, must be treated as doubtful, or, at all events, is unestablished." Tournal at the same time allows that it is possible the human bones and the specimens of living species of shells found in the Bize caverns may have been carried in by subsequent currents of water, which rearranged the contents of the caves.

The human bones, he tells us, were found with pieces of pottery, living marine and land shells, and bones of extinct animals, in the same stratum of red cave earth (*Annales des Sciences Naturelles*, vol. xv, pp. 348–350). He adds another statement, which he did not, and perhaps could hardly be expected to, appreciate at its full value, that he also found in the cave earth fragments of flint with very sharp angles ("des fragments de silex pyromaque à angles très-vîfs").

On the 29th of June, 1829, M. Christol communicated to the Academy a notice of the caverns of Pondres and Souvignargues, near Sommières, explored by himself and M. Emilien Dumas. He was convinced that these caverns proved incontestably the mixing of human bones with those of extinct animals, and M. Cordier, the reporter of the paper, thought the facts of the deepest interest (id., p. 93), but the value of the observation is qualified by the fact that he claims to have found pieces of pottery at all levels in the cave. In a second communication made to the *Annales des Sciences* in 1829 (op. cit., vol. xviii, p. 247; and Bull. Sci. Nat., ch. xix, pp. 18–28), Tournal, referring to the recent researches of Christol just mentioned, says that they confirmed what he had long maintained, that man was contemporary with the extinct animals. He says that Christol had shown him human bones which he had found at a great depth in the caverns of the Gard, and that it was impossible to separate them in regard to condition from those of the lion, tiger, and the hyæna found with them; their chemical and physical condition was the same. In regard to the caverns of the Bize, he added the fresh fact that certain of the animals' bones had marks of human workmanship upon them. Tournal concludes his paper with a sentence which, as M. Cartailhac says, has the audacity of genius, considering that it was written in 1829. "La géologie," he says, "commence là ou l'archéologie s'arrête: lorsque celle-ci aura épuisé ces recherches et rencontré le voile mystérieux et impénétrable que couvre l'origine des nations, la géologie donnant un supplément à nos courtes annales, viendra réveiller l'orgueil humain, en lui montrant l'antiquité de sa race; car la géologie seul peut désormais nous donner quelques notions sur l'époque de la première apparition de l'homme sur le globe terrestre."

It is a matter of regret that the caves so diligently explored by Tournal should have had their contents disturbed and rearranged by secondary burials, and should have differed in this respect from those at Gailenreuth, where the stratum containing the extinct animals was apparently intact. The early French explorers were also not sufficiently careful in their digging to separate the different layers, nor was it known at that time that so-called Palæolithic man had not learnt the use of pottery.

These difficulties in a measure justified the scepticism of Cuvier, and led to these French discoveries and their importance being underrated, but when we have discounted the adventitious elements in them we cannot doubt that the human bones (especially those found by Tournal) were found together with the extinct ones in

these caves in a way which makes it clear they were contemporary. This was the view of M. Marcel de Serres, to whom the question was remitted for examination by the French Academy, and who had the human bones analyzed, when they were found to have parted with their animal matter to as great a degree as those of the hyænas which accompanied them, to be equally brittle, and to adhere as much to the tongue, and were quite different in these respects from some bones from an ancient Gaulish cemetery with which they were compared by M. Ballard, a chemist of Montpelier.

Cuvier's authority, however, was supreme in France on these questions, and he was immovable. I quoted in the previous paper the pronouncement he made in 1830 in the last edition of his famous "Discours," reaffirming his scepticism as to man having been contemporary with the extinct animals. Two years later he died.

In concluding this first stage of the inquiry I would complete it by quoting a passage from Mortillet:—"Le grand Cuvier, le père de la paléontologie, a reconnu et proclamé que l'homme fossile n'exista pas! . . . Toujours le principe d'autorité qui vient barrer le chemin au libre examen. . . . C'est que chez Georges Cuvier, à côté du savant de premier ordre, à côté de l'homme de génie dont la France et le monde entier s'honorent, il y avait l'ardent bibliste. L'illustre professeur du Muséum, créant une science nouvelle, était doublé d'un médiocre conseiller d'état se posant en défenseur de ce qu'alors, comme à présent, on nommait l'ordre moral. Mais que pèse et que doit peser le sentiment intéressé de Cuvier devant la voix suprème de faits bien constatés." ("Le Préhistorique," pp. 10–11.)

The death of Cuvier did not stop the inquiries into the early existence of man, which now took a more definite shape and were especially pressed home by Schmerling. In 1833 Schmerling published his famous "Recherches sur les ossemens fossiles découverts dans les cavernes de la province de Liége." In this work he seems to me to have established beyond all possible doubt the contemporaneousness of man and the extinct animals, and he contests the *à priori* prejudice of De Luc and Cuvier, who denied the existence of fossil human bones. In regard to the main question he writes—and it would be impossible to write more wisely:—"We admit that we are completely ignorant of the precise period when man first appeared on the earth. History seems here to abandon us, and we are lost in the obscurities of mythology and of different cosmogonies; but if antiquity has left us no positive documents on the subject, it yet informs us of a certain intellectual progress in our race. No one doubts that men were once in a state of ignorance in which they approached the brute creation, only caring for the supply of their immediate wants. History only gives us vague, uncertain, and even contradictory notions on the origin of the early peoples, but it seems impossible to doubt that man was the witness of the terrible revolutions which succeeded each other before historic times. . . . It is in the great book of Nature that we ought to search for light

when history gives us only vague and uncertain information." Turning then to his own researches, he says that what they put beyond doubt is, that human bones were buried at the same period and by the same cause as those of the extinct animals. He then goes on to describe in detail the human remains, comprising those of three individuals, which he had found in the cave of Engis, and which, he said, were surrounded by those of the elephant, the rhinoceros, and of extinct carnivores. He also describes a larger number of human bones found in the adjoining cave of Engihoul, where they were covered by stalagmite. These bones, he says, agree in colour, in the degree of decomposition, and in the way they occur with those of the extinct beasts; all the bones of the extremities were broken, as in the case of the other animals, and the stalagmite had penetrated into and covered the fractured faces with a deposit. He concludes the detailed account of the bones with the words: "J'ai fini par conclure que ces restes humains ont été enfouis dans ces cavernes à la même époque, et conséquent par les mêmes causes qui y ont entrainé une masse d'ossemens de différentes espèces éteintes. . . . L'homme, sans contredit, existait avant le dernier bouleversement de notre planète."

In a later chapter, in his second volume, published in 1834, Schmerling describes how, in an exploration subsequent to those described in his first volume, he had found certain objects fashioned by human hands. Thus, in the cave of Chokier he found among a number of rhinoceros teeth a triangular piece of bone cut from another which was artificially pierced, roughly tooled, and polished. Another piece of bone found in the Engis cave was pointed; it was partially covered with stalagmite. In the cavern of the Fond de Forêt he found some pieces of worked bone and horn. These he figures, as he does certain flint fragments, of which he says: "La forme régulière a frappé, au premier abord, mon attention. Dans toutes les cavernes de notre province où j'ai trouvé des ossemens fossiles en abondance, j'ai aussi rencontré une quantité, plus ou moins considérable, de ces silex." In regard to these flints he says—and mark, this was printed in 1834:—"Ces silex sont d'une longueur et d'une largeur variables; ils ont une face plane et une triangulaire, les faces étant à-peu-près de même dimension; les bords externes sont très tranchans, mais les extrémités sont obtuses. Ce que prouve que ces silex ont été longtemps exposés aux influences atmosphériques avant d'avoir été enfouis dans les cavernes, c'est qu'ils sont tous couverts d'une croûte blanchâtre qui, dans quelques-uns que j'ai brisés, ne dépasse pas l'épaisseur d'une ligne, tandis que le centre est d'un gris bleuâtre. La forme de ces silex est tellement régulière qu'il est impossible de les confondre avec ceux que l'on rencontre dans la craie et dans le terrain tertiaire. Toute reflexion faite, il faut admettre que ces silex ont été taillés par la main de l'homme, et qu'ils ont pu servir pour faire des fleches ou des couteaux. . . . Le gîte de ces os et de ces silex n'avait pas laissé matière à quelque doute, c'est à dire que un accident quelconque avait put amener ces pièces dans les cavernes après

leur remplissage. . . . J'ose garantie qu'aucune de ces pièces n'a été introduite après coup. . . . Si enfin, comme en Allemagne et en France, plusieurs de ces cavernes eussent été connues depuis longtemps, et eussent servis à l'époque du moyen âge, sort de refuge ou de cimetière, certes nous aurions eu tort d'attacher la moindre importance aux débris que nous avons trouvés; mais nous répétons que, tout ce que nous avons dit sur les ossemens humains, est exact et sans réplique. Le temps seul, au reste, décidera jusqu'à quel point nous avons eu raison de nous exprimer d'une manière aussi catégorique, et aucun géologue éclairé ne voudrait soutenir aujourd'hui que l'homme n'existait point à l'époque où nos cavernes ont été comblées du limon et des fossiles qu'elles recélent." This is plain and definite, and it is the view now held everywhere. Unfortunately his own generation were deaf to Schmerling's appeals.

In the supplementary notes to his Bridgewater treatise, published in 1837, Buckland tells us that in September, 1835, he had seen the extensive collection of fossil bones made by M. Schmerling in the caverns of the neighbourhood of Liége. He says:—"The human bones found in these caves are in a state of less decay than those of the extinct species of beasts; they are accompanied by rude flint knives and other instruments of flint and bone, and are probably derived from uncivilized tribes that inhabited the caves. Some of the human bones may also be the remains of individuals who, in more recent times, have been buried in such convenient repositories. M. Schmerling, in his 'Recherches sur les Ossemens Fossiles des Cavernes de Liége,' expresses his opinion that these human bones are coeval with those of the quadrupeds, of extinct species, found with them; an opinion from which the author, after a careful examination of M. Schmerling's collection, entirely dissents." (Op. cit., p. 602.)

In the third edition of his "Principles of Geology," Lyell merely mentions Schmerling's discoveries and the latter's claim that he had found human remains with those of extinct animals, but expresses no opinion on them. This was after he had paid a visit to Schmerling in 1833. Lyell confesses that he expressed incredulity to his host about the alleged antiquity of the fossil bones in his "Antiquity of Man"; he frankly avows that in the third and subsequent editions of his famous "Principles" he had failed to give Schmerling's discoveries the weight to which they were entitled, and adds—"He [i.e. Schmerling] had accumulated ample evidence to prove that man had been introduced into the earth at an earlier period than geologists were then willing to believe," and he goes on to excuse and apologize, like the brave honest person he was, for what he had done. The words are worth quoting. "To have undertaken," he says, "in 1832, with a view of testing its truth [i.e. the truth of the discovery], to follow the Belgian philosopher through every stage of his observations and proofs, would have been no easy task even for one well skilled in geology and osteology. To be let down, as Schmerling was day after day, by a rope tied to a tree, so as to slide to the first opening of the Engis cave, where the best preserved human skulls were found; and, after thus gaining access to the first subterranean

gallery, to creep on all fours through a contracted passage to larger chambers, there to superintend by torchlight, week after week and year after year, the workmen who were breaking through the stalagmitic crust, as hard as marble, in order to remove piece by piece the underlying bone-breccia, nearly as hard; to stand for hours with one's feet in the mud, and with water dripping from the roof on one's head, in order to mark the position and guard against the loss of each single bone of a skeleton; and at length, after finding leisure, strength, and courage for all these operations, to look forward as the fruits of one's labour, to the publication of unwelcome intelligence, opposed to the prepossessions of the scientific as well as of the unscientific public;—when these circumstances are taken into account, we need scarcely wonder, not only that a passing traveller failed to stop and scrutinize the evidence, but that a quarter of a century should have elapsed before even the neighbouring professors of the University of Liége came forth to vindicate the truthfulness of their indefatigable and clear-sighted countryman." That is a handsome reparation, but it came long after Schmerling had gone away to other hunting-grounds. He died in 1836, a poor and disappointed man. Let us all take our hats off to him!

IV.—Further Note on the Westleton Beds.[1]

By Horace B. Woodward, F.R.S.

THE view expressed in 1882 that the Westleton Beds of Westleton, in Suffolk, form part of the Middle Glacial division of S. V. Wood, jun., was strengthened by observations made at Southwold in 1895, and is supported by sections examined last year near Lowestoft.[2]

In Prestwich's original description of the "Westleton Sands and Shingle," he remarked that "they attain a thickness of from 30 to 40 feet, and consist of a series of stratified beds of well-rounded flint-pebbles imbedded in white sand, and with two or three subordinate beds of light-coloured clay."[3] These are the true Westleton Beds, which are exposed in pits on Westleton Moor or Common, and which extend across Westleton Heath to the cliff at Dunwich, where they rest on the Crag Series and are overlain by Chalky Boulder-clay.

In his later paper on the Westleton Beds, Prestwich took into the group a greater thickness of strata at Westleton, his "General Section" including 20 feet of "white sand passing down into ochreous pebbly sands with a few large unworn blocks of flint and some ironstone bands and concretions," which occurred below the mass of the Westleton Beds, so clearly described in his preceding statement.[4] Altogether he took in about 54 feet of strata, and although he mentioned that no fossils were met with in this

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.
[2] Geol. Mag., Dec. II, Vol. IX, p. 452; Dec. IV, Vol. III, p. 357.
[3] Quart. Journ. Geol. Soc., 1871, vol. xxvii, p. 461.
[4] Ibid., 1890, vol. xlvi, p. 96.

"General Section on Westleton Common," yet in another pit on the Common he found "in digging a few feet lower, a sandy clay with very friable specimens of *Tellina* and *Natica*."

There can be little doubt that in this "General Section" the lower white and ochreous pebbly sands belong to the Crag Series, upon which as at Dunwich the Westleton Beds directly rest; and that this Pliocene formation, as Mr. Whitaker has shown, occupies a large area and forms a great portion of the Dunwich cliff.[1]

In my opinion Prestwich's original section (though diagrammatic) expresses the facts better than do his later statements. Therein the Westleton Shingle at Dunwich, that directly underlies the Boulder-clay, was rightly placed by him in the Middle Glacial ("Boulder Sands and Gravels"), while he grouped the beds at the base of the cliff, which are well known to be Crag, with the mass of the pebble-beds of Southwold. With this latter correlation also I entirely agree; both belong to the Crag Series, though Prestwich grouped both as Westleton sands and shingle. Thus troubles arose from the correlation of the Southwold shingle with that at Westleton, and they have been complicated by the inclusion of part of the Crag Series at Westleton with the Westleton Beds.[2]

Mr. C. Reid has pointed out that the shelly exposures which have been noted in the Southwold pebbly gravel in the cliff north of the town, at a pit on the Lowestoft Road, and at Southwold Station, contain a fauna identical with that of the Norwich Crag.[3] As we pass on to Easton Bavent we again see a mass of similar pebbly gravel, divided by a band of Chillesford Clay which thickens northward; and the whole in my opinion belongs to the Crag Series, with the exception perhaps of a thin gravelly covering here and there. These beds are not to be compared with the 30 or 40 feet of Westleton Beds at Westleton. As Mr. A. E. Salter has remarked, here "we have *two distinct kinds* of gravel."[4]

A section identical with that on Westleton Common is to be seen in a large pit north of the Southwold railway, where it branches off from the main line. No one would dispute that here we have the true Westleton Beds, and here they are overlain by the Chalky Boulder-clay, which was lately so well exposed in the adjacent cutting by Halesworth Station.

A glance at the Geological Survey Map shows that the separation of the pebble-beds from the Glacial sands and gravels may often be taken as a lithological rather than as a stratigraphical division, and that there is work still to be done in separating Pliocene from Glacial deposits.

There is abundant evidence to show that the buff sands which characterize the Middle Glacial Drift over large areas in East Anglia do contain bands, and here and there masses, of shingle like that of Westleton.

[1] "Geology of Southwold" (Geol. Survey), 1887.
[2] Proc. Geol. Assoc., vol. xv, p. 440.
[3] "Pliocene Deposits of Britain," p. 104.
[4] Proc. Geol. Assoc., 1896, vol. xiv, p. 398.

At Pakefield gap the Boulder-clay is well seen occupying a hollow above the Middle Glacial sand, which contains occasional seams of shingle. Further on, towards Lowestoft, near the Grand Hotel at Kirkley, the cliff shows the sands with shingle dovetailing into it, and forming the mass of the cliff to a height of 15 feet. Below the Grand Hotel a similar section, for the most part shingle, is to be seen.

Here we have conclusive evidence that the Middle Glacial sands are replaced by shingle identical in character with the Westleton Beds of Westleton. The occurrence of this pebble-bed in the Middle Glacial sand was noted by J. H. Blake, but its significance was not pointed out.[1]

Again, a large gravel-pit east of Oulton Broad (formerly Mutford) Station shows about 40 feet of white and buff sands passing down into a mass of shingle, with the sand dovetailing into it as in the cliff at Kirkley.

In the country to the north, between Lowestoft and Loddon, Reedham and Gorleston, there are other sections, as at Thorpe-next-Haddiscoe, which furnish similar evidence.[2]

In this region we are also brought into contact with a newer pebbly gravel, which has been largely derived from the Middle Glacial shingle-beds. It is on the whole coarser and more intermixed with angular and subangular flints than the local shingle-beds of Oulton, Kirkley, Halesworth, and Westleton; but very different from the boulder or 'cannon-shot' gravel of Mousehold, near Norwich. It, however, forms a portion of the "plateau gravel, sand, and loam" mapped and described by J. H. Blake as newer than the Chalky Boulder-clay.[3] It is interesting and at times perplexing. Sections along the new Yarmouth and Lowestoft direct railway north-west of Belle Vue Park, Lowestoft, and in the Oulton pit (before mentioned), show masses of this rather coarse pebbly gravel resting in places with apparent conformity, and elsewhere with marked irregularity, on the Middle Glacial sands and gravels. There would, however, be no justification in making a distinction were it not the fact that the coarser gravel does extend over the Chalky Boulder-clay, as may be observed in a large sand-pit east of Burton Cottages on the western side of Lowestoft.

Above Normanston, at the brickworks along Woods Loke, west of St. Margaret's Church, Lowestoft, the Boulder-clay is overlain by a bed of brown laminated carbonaceous loam, somewhat disturbed in places, and with pockets of sand and gravel. The loamy bed may perhaps be compared with the lacustrine bed at South Elmham described by Mr. C. Candler;[4] at any rate, it appears to mark a stage prior to the accumulation of the Plateau gravel, which rests irregularly on any of the older drifts.

[1] "Geology of Yarmouth and Lowestoft" (Geol. Survey), 1890, p. 38.
[2] Geol. Mag., 1882, p. 455; see also J. H. Blake, Geol. Yarmouth and Lowestoft, pp. 43, 44, etc.
[3] Geol. Yarmouth and Lowestoft, pp. 5, 44, 57, 61.
[4] Quart. Journ. Geol. Soc., vol. xlv, p. 504.

In this region of East Anglia we have evidence of pebbly gravels in the Crag Series, in the Middle Glacial (Westleton Beds), and in the Plateau Drift.

Where one gravel is largely derived from another and is welded on to it, there must often be difficulty in fixing a plane of demarcation, as there would be (in the absence of fossils) in separating other strata of identical lithological character.

Similar occurrences, observed in Egypt by Mr. H. J. L. Beadnell, where Cretaceous and Eocene clays appear to merge together, though not in uninterrupted sequence, have been aptly referred to by him as "*unconformable passage-beds.*"[1] The term is at any rate a useful one to bear in mind in connection with gravels, ancient and modern.

V.—The Petrographical Characters of the Darjíling Gneiss.

By John Parkinson, F.G.S.

WELL known as Darjíling is to nearly every stray traveller in India, the solid geology of the district has been left almost (I believe quite) untouched since the publication of Mallet's paper[2] in 1874. There the Darjíling gneiss was described as the metamorphosed representative of the sedimentary Gondwana rocks of the south, and has so remained, albeit under protest, for a disclaiming paragraph[3] appears in the Manual of the Geology of India. In the report of the Committee[4] on the recent landslip at Darjíling it is stated that the rock of the country consists of "a well foliated and banded biotite gneiss with occasional lenses and deformed veins of granitic rock"; moreover, that "the foliation planes are often highly contorted"; and Mallet defines it as true gneiss "passing into mica schist or an intermediate variety." These descriptions are meagre, and it is hoped that the following notes on specimens collected by the author may not be superfluous.

Description.

The gneiss outcropping near the Jelapahar Road, on the eastern side of the ridge on which Darjíling stands, is a streaky or roughly banded, rather massive rock, the planes of greatest fissility glittering with black mica and containing a few pink garnets the size of a small pea. In a thin section (Fig. 1) the mica is the most conspicuous mineral. It is a dark green to reddish brown for vibrations parallel to the basal plane, and of a deep straw colour for those at right angles. The irregularly shaped garnets are very pale pink in colour, cracked, and rather dirty. The colourless constituents slightly predominate, and consist largely of quartz with orthoclase and plagioclase; some crystals of the former felspar exhibit a microperthitic intergrowth; the latter is rare and apparently

[1] Report iii, Geol. Survey of Egypt, Cairo, 1901.
[2] Mem. Geol. Surv. Ind., 1874, vol. xi, pt. 1.
[3] Geology of India, 2nd ed., p. 76.
[4] Report of the Committee on the Landslip at Darjeeling, September, 1899; published October, 1899.

albite or oligoclase. The quartz also occurs sparingly as 'quartz vermiculé.'[1] In addition, the rock contains a few grains of zircon and some crystals of an iron-oxide, probably hematite. This completes the list of constituents with the exception of a fibrous mineral seemingly derived from the mica. Loss of the characteristic colour and pleochroism precede the assumption of the fibrous appearance. It then consists of a felted mass of crystals which are of a brown colour in the aggregate by an ordinary light and exhibit a rather vivid polarization. Finally, the brown colour is entirely lost and the constituent crystals fray out in a brush-like way. The mineral is no doubt sillimanite, and the thin section as a whole forcibly recalls some of the fibrolite and cordierite gneisses of Germany. The Darjíling rock is therefore a garnetiferous sillimanite gneiss, in which the presence of cordierite is to be suspected. This mineral no doubt does occur, but the rock has suffered slightly from pressure and the felspars are usually fresh and unaltered; facts not conducive to the ready determination of such a mineral as cordierite, which appears to be free from its characteristic decomposition products. The inclusion of one mineral by another is a characteristic feature; e.g., rounded 'spots' of mica are often present in the quartz, or of quartz in the felspar. The larger quartz grains are much cracked and the lines of fracture marked by infiltrated substances. A cementing of the parts has, however, always taken place.

A specimen from a roadside outcrop below Tigar Hill is a massive rock with a distinct foliation;[2] distinguished by a large quantity of silvery-brown mica, many of the flakes measuring ·15 inch across. In a thin section two micas are conspicuous—a reddish brown, recalling that of some Kinzigites, and a white. They occur closely associated, so that thin laminæ of the brown mineral are found inserted parallel or, occasionally, transversely to the basal cleavage of the white. Sillimanite is locally mixed up with films of the latter, and possibly the rock contains cordierite. Felspar is rare, and the slide contains much quartz, exhibiting very irregular outlines. Some large apatite grains (·1 inch across), considerably cracked, are also characteristic, as well as numerous small zircons. A pale yellow stain, together with the absence of a basal cleavage, in some of the white micas suggest this mineral is not always normal. A third specimen, collected near the last, shows a well-marked wrinkled structure. It contains a few irregular, but not torn, garnets, and a good deal of sillimanite associated with white filmy mica, as in the preceding slide.

The rock figured is the common type of the Darjíling gneiss, and in this bands of finer texture occur, one of which from the Rungeet Road has been sliced. Macroscopically, the constituent minerals

[1] By this term is meant the thread-like intergrowth of quartz in felspar. The branching threads are grouped often in a kind of bunch, not uncommonly radiating from a point. In the examples I have met with I believe it to be an original structure.

[2] This rock differs in appearance from the others that I collected. The specimen is browner in colour, the flakes of mica more conspicuous, and the foliation less marked.

are only just discernible to the naked eye, and the presence of mica gives it a uniform grey tint. Part of the specimen is a much coarser compound of quartz and rather decomposed felspar, with but a few flakes of mica, and containing a band, ·1 to ·15 inch thick, consisting almost entirely of the last-named mineral. The thin section shows the part of finer grain to consist of the following constituents, the whole rather crushed: brown mica which is plentiful, some white mica in part secondary, zircon fairly common, garnet rare, quartz the most abundant mineral, orthoclase and plagioclase. The felspars are commoner in some parts of the slide than in others. The plagioclase, which appears to be albite or oligoclase, is often rather unusually translucent. The quartz forms large irregular grains, and occasionally occurs as quartz vermiculé. The orthoclase frequently contains a microperthite intergrowth. Sillimanite is found in another specimen from the same locality.

Fig. 1.—Usual type of the Darjiling gneiss, × 20. An irregular crystal of garnet appears on the left side towards the top of the stage. Near it are crystals of white mica (*m.w.*). The centre of the field is occupied by brown mica (*m.b.*); basal sections are cross-hatched. Sillimanite (*sl.*) is seen on the left side. The rest of the section is composed of orthoclase (*of.*), quartz (*q.*), and a single grain of sphene (*s.*).

Amongst a pile of trimmed blocks by the roadside, I found one with a hard nodule-like 'eye' some six inches across, surrounded by the ordinary gneiss. The whole of the periphery was not seen, but the mica folia of the gneiss appeared to bend round it. Fracture, texture, and composition distinguish this inclusion from the ordinary rock. It is hard and compact with no conspicuous foliation, and breaks with almost equal ease in any direction. It has a rather dirty grey appearance from the presence of black specks of mica, ·007 inch and under in length, and it is faintly mottled by pinkish patches consisting of clusters of garnet grains, each group being roughly ·1 inch across. Under the microscope two principal constituents appear in addition to the garnet, viz. quartz and felspar. The latter forms an allotriomorphic network, indented and embayed

by large quartz crystals and honeycombed by a pegmatitic intergrowth of the same mineral. A large grain adjacent to a felspar does not as a rule send offshoots into it. Only small groups of the quartz granules polarize together, though we find exceptions. Nearly one-half of the felspar shows no twinning, and the remainder, judging by the extinction measured parallel to the trace of the plane of twinning, is much more basic than might be supposed, symmetrical angles ranging from 35° to 40°. The larger quartz grains exhibit rows of inclusions parallel the one to the other. The garnets are a pale claret-red, subangular in outline, and occasionally making an attempt at idiomorphism, and rather cleaner than those of the gneiss. Grains of zircon and sphene are not uncommon. Flakes of brown mica are scattered sparingly and rather irregularly across the slide.

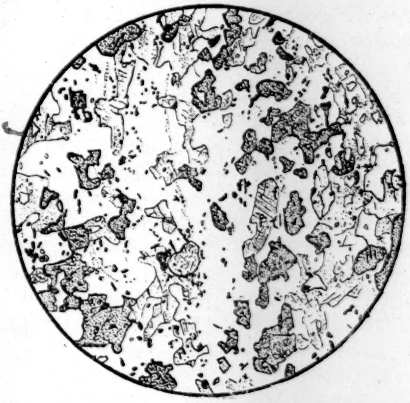

FIG. 2.—Nodule-like inclusion, × 20. Near the centre of the stage, or slightly below it, the following letters are placed to indicate the various constituents: *gt.* garnet, *p.* plagioclase (faintly dotted), *gr.* graphite, *q.* quartz (colourless), *i.* ? idocrase, *s.* sphene. The small colourless microlites mentioned in the text are also indicated.

Passing away from the centre of this 'eye' towards the surrounding gneiss, we find that this hard and compact rock graduates into one of slightly granular texture, rather whiter and containing larger flakes of brown mica and less clear garnet spots. A thin section cut near the junction shows the latter mineral associated with some good-sized crystals of sphene.[1]

On the western side of the ridge the same general characters are repeated. Thus, on the road from Darjiling to Ghoom, a common type of the gneiss contains numerous streaks or elongated lenticles of quartz and felspar, arranged usually in an undulating manner and occasionally retort-shaped in section. The rock weathers to a grey tint and contains characteristically a rather large quantity of mica. A hard lenticle or eye, resembling that noticed as occurring in the gneiss of the Rungeet Road, was found in this rock. The length was

[1] Occasionally ·02 inch long. The slide contains a little augite.

about 9 inches, the thickness 2·5 inches. The specimen was rather darker in colour than that above described, with a siliceous aspect, and faintly mottled with red garnets (Fig. 2). The quartz grains are subangular in outline, occasionally exhibiting crush shadows. They contain very many small crystals of a colourless mineral in the form of prisms having lath-shaped sections, which I am unable to name. The groups of garnet grains show a distinct attempt at a general linear arrangement, and a similar elongation occurs in all the minerals. The slide contains sphene and at least two other minerals which are noteworthy. I am indebted to Canon T. G. Bonney for suggestions concerning these. First, a considerable quantity of an opaque mineral characterized by its elongated shape (commonly about ·0038 × ·00055 inches). The outlines are rather jagged and uneven, the colour by incident light is grey, and the lustre metallic. It is associated with a little specular iron, which is also met with elsewhere in the slide. In order to test the streak I powdered a small quantity of the rock, and by means of a lens isolated a few of the black flakes and pressed them with a knife blade upon a sheet of notepaper. They yielded readily to the pressure and left a dull grey mark. I concluded, accordingly, that the mineral is graphite. It occurs, though less plentifully, in slides of other nodular eyes. The second mineral usually forms small and more or less rounded grains. An idiomorphic outline is sometimes indicated by the occurrence of stumpy rectangles, (extinction takes place parallel to the sides) with unequally truncated corners. The refractive index is higher than that of apatite, to which we see a resemblance in double refraction, slightly bluish colour, roughened aspect, and absence of cleavage. A grain occasionally appears isotropic. I incline to refer the mineral, but with hesitation, to idocrase.

Another specimen from the same locality, as seen in a thin section, consists of a network of large quartz grains and very irregular plagioclase, exhibiting as before much micropegmatitic quartz. Garnets, some dozen grains of sphene, and a number of mica flakes make up the rest of the slide.

On the western side of the Darjiling ridge, near St. Joseph's College, scattered sections of the gneiss are found sufficient to enable its characters to be studied. The rock is frequently gnarled with irregular bands; once I saw such a one, rich in quartz and felspar, diminish in thickness in 3 feet from 9 inches to 2·5 inches. Close by, a broad band at least a foot across was streaked and veined irregularly by darker, i.e. by more micaceous, material. Parallel to this were others shaped like very elongated lenticles. Again, the gneiss on Birch Hill Road was occasionally beautifully puckered in successive V's; and some infiltration veins had been formed subsequently to the folding. The gneiss *in situ* about three-quarters of a mile from Darjiling is a finely foliated, slabby rock of medium grain, containing a considerable quantity of mica. A thin section discloses the presence of sillimanite, white and brown micas, and a few irregular pinkish garnets about ·04 inch

across. The very irregular grains of quartz are frequently cracked and show crush shadows. Plagioclase is not uncommon, zircon as before, and some quartz vermiculé. Possibly the rock contains cordierite.

Conclusions.

One characteristic feature of the rock, the irregular outline of the grains and the inclusion, or partial inclusion, of one mineral by another, may, in my opinion, be best explained as the result of movement in a somewhat viscous mass. The cracked quartzes and garnets, the lines of fracture in which are now healed, together with a confused grouping often found among the smaller particles of quartz and felspar, indicate that, at one time, the rock has suffered from the effects of crush, from which it subsequently, more or less completely, recovered. The outlines of the quartz and felspar, which, as just remarked, may be accounted for by fluxional movement, at the same time suggest that pressure has been at work forcing them, as it were, into the minimum space.

The presence of sillimanite and probably of cordierite, which render the alumina percentage unusually high,[1] may possibly be due to an incorporation of argillaceous material, although no obvious reason exists why the magma may not have been exceptionally rich in this constituent from the beginning. However this may be, the Darjiling gneiss is certainly not a result of the metamorphosis of Gondwana beds.

Another point requiring elucidation is the presence of the hard siliceous 'eyes.' Conceivably during the movement preceding its solidification, the magma picked up small fragments of a foreign rock, which, being softened and permeated by their liquid surroundings, have resulted in the mineral assemblage seen. The graphite must have formed, if not from igneous fusion, then from a state closely approaching it. The structure as a whole is indicative of crystallization where freedom of molecular movement was restricted.[2]

To Canon T. G. Bonney I am indebted for many valuable suggestions which are embodied in the preceding notes.

NOTICES OF MEMOIRS.

I.—Ice-Erosion in the Cuillin Hills, Skye. By Alfred Harker, M.A., F.G.S. Trans. Royal Soc. Edinburgh, 1901, vol. xl, pt. 2, pp. 221–252.

"Those who are interested in hill-climbing will know that "Sligachan, in Skye, is the rock-climbing centre *par excellence* of the British Isles"; and as Mr. Charles Pilkington further remarks in the fascinating Badminton volume on Mountaineering, "The Alpine climber will find an additional interest in the district from

[1] See Mr. J. J. H. Teall's Pres. Address to Geol. Assoc., Proc. Geol. Assoc., 1899, vol. xvi, pp. 72, 73.

[2] See paper by Canon T. G. Bonney, Quart. Journ. Geol. Soc., 1891, vol. xlvii, p. 105.

the remarkable indications of former glaciers; in some places it would seem as if they had disappeared but a few years previously, and occasionally, whilst climbing some smoothly rounded buttress, one almost expects to see the ice itself creeping through the next depression."

More than fifty years ago J. D. Forbes drew attention to the traces of ancient glaciers in the Cuillin Hills, but it has remained for Mr. Alfred Harker to work out and portray in masterly style the somewhat complex glacial history of this mountainous region.

The Cuillins, though formed of rocks wholly younger in age than the London Clay, are better entitled to take rank as mountains than any other elevations in Britain. The main range takes a semi-circular form; it is built up of a great laccolitic mass of gabbro, and its sharp and rugged peaks rise in many places above 3,000 feet. Separated from these by Glen Sligachan is a range of 'Red Hills' formed of granite and granophyre, whose smooth and dome-like elevations, mostly under 2,500 feet, appear in marked contrast both in colour and outline with their dark and grim neighbours. Those who tread the stony track-way from the Sligachan Hotel to Loch Coruisk, may feel fatigue at the end of their journey, but they cannot fail to be fascinated with the grandeur of the Glen.

Mr. Harker points out that during the period of maximum glaciation these Skye mountains sustained a small local ice-cap, round which the great Scottish ice-sheet flowed north-westwards and south-eastwards, traversing the peninsula of Sleat, the islands of Pabba and Raasay, and that portion of Skye which lies north of Portree. Both the Cuillins and the Red Hills afforded gathering-ground for the local ice, under which they came to be wholly buried, for its thickness was probably not less than 3,000 feet. This local ice and that of the Scottish sheet were in equilibrium for a long time along their line of confluence; but the movements of the local ice are indicated by the directions of striæ on rock-surfaces, and by the distribution of boulders of local and recognizable rock-types. There is a noticeable absence of foreign boulders in central Skye, except near the shore, where they occur occasionally up to as much as 75 feet above sea-level. Along this margin, however, there are relics of the 'hundred foot' raised beach, which prove that the land stood lower by that amount at the close of the Glacial Period.

Interesting observations are made on the movement of the ice during the great glaciation, and it is pointed out that the striæ necessarily give only the direction of movement of the lower layers of the ice, and this appears to be true also in great measure of the dispersal of boulders.

The natural outward flow of the ice was in general closely guided, as regards its lower layers, by the form of the ground, but as the land for many miles from the Cuillins was wholly buried in ice, the form of the ground exerted only a partial control over the direction of flow. Thus it is not improbable that the upper layers followed in places a somewhat different course from that proved with regard to the lower layers.

The author points out that while the carving out of the main features of mountain and valley was due to aqueous erosion in pre-Glacial times, the actual details of the relief are due to the action of ice and frost during the Great Ice Age. Before glaciation the drainage system was a fully established one, and erosion was practically at a standstill, as it is under present conditions.[1] Hence the effects of ice and frost action remain practically without modification by later agencies; and almost every square foot of the surface bears the stamp of glaciation. It is clear, as the author remarks, that the ice has been in close contact, throughout its whole extent, with the subjacent rocks, and has forced its way into hollows and openings, vertically and horizontally, in a fashion which argues effective plasticity in its lower layers.

He points out that it is practicable to distinguish the features due to glacial from those due to aqueous erosion. The work of the ice was something more than a mere excoriation of the surface, and in comparing the work of ice and of water he observes that "a sand-grain gripped in the sole of a glacier, or of an ice-sheet thousands of feet in thickness, must be incomparably more efficient as a graving tool than the same grain rolled along the bed of a stream." Ice-action, then, must be rapid compared with that of running water; its work is done, moreover, with little or no chemical co-operation, and instead of the relief produced by ordinary weathering agents, features are carved out of the rock-complex in a fashion wholly irrespective of lithological differences or geological structure. Lateral erosion, too, comes in unfettered by any consideration of 'base-level,' and valleys may be widened as well as deepened and their sides straightened.

Attention is drawn to the formation of cirques or corries and of small rock-basins on their floors. The erosion of these was dependent upon an adequate supply of débris or abrading material at the under surface of the ice, and as the excavation of the higher cirques proceeded the dividing ridges became intensified. On the principal ridges, which acted as ice-sheds, ice-erosion necessarily failed for want of a tool to work with.

The author observes that if we take the Cuillin district as a type, it appears that ice-erosion does not, like water-erosion, work constantly towards the establishment of an even gradient along a valley in which it operates. Erosion will be most efficient when the pressure below the ice is greatest, that is, when the thickness is greatest, and differential erosion will operate so as to exaggerate inequalities. This would be arrested when the lower layers of the ice begin to be ponded in the lee of a strong feature, and the upper layers slide over them. Thus, rock-basins in valleys are dependent not merely on glacial erosion, but on glacial erosion operating under certain local conditions and in more than one way. Detailed observations and soundings made by the author and

[1] See article by A. Harker on Subaërial Erosion in the Isle of Skye: Geol. Mag., 1899, p. 485.

Mr. T. A. Falcon on Loch Coruisk, show that it occupies an area of two rock-basins, which have been excavated by ice-action.

Evidence is brought forward to show that succeeding the great glaciation there was a minor glaciation due to the action of glaciers occupying the valleys, at a time when the obstruction caused by the Scottish ice-sheet had been removed, and when the Skye ice was free to follow a course more in accordance with local topography. The author observes that the distribution of the cirques suggests a connection with the direction of sunshine; that the asymmetric character of the ridges and valleys in the outer parts of the mountain area may be attributed to the different aspects of the slopes relatively to the sun; and that therefore this influence was exerted, not at the time of maximum glaciation, but when the ice-cap had shrunk so as to occupy the valleys alone, and during the later glaciation, which was effected by glaciers only. He has not attempted in all cases to apportion the work of erosion between the ice-cap and the glaciers. His further detailed observations on the drift deposits, on the distribution of boulders, on perched blocks, and on the formation of screes will be read with profit. They furnish evidence of his careful methods of research, and of the impartial way in which on all occasions he interprets the facts.

II.—The Granite of Tulloch Burn, Ayrshire. By Professor James Geikie, F.R.S., and John S. Flett, M.A., D.Sc.[1]

THE granite of Tulloch Burn, Ayrshire, is a small mass occupying an area of three or four square miles on the headwaters of the Irvine and the Avon. Much of the outcrop is covered with drift and peat, but good exposures of the granite and the contact-altered rocks can be obtained in the Tulloch Burn, a tributary of the Irvine, and on the Avon. The prevalent type is a flesh-coloured biotite-granite, which often contains hornblende and sometimes decomposed augite. This passes at its margins into rocks of intermediate or basic composition, which include various types of diorite, hyperite, and gabbro. The evidence points to the origin of these rocks by a process of differentiation, and both in this respect and in the rock species which have been developed the resemblance to the granites of the Southern Uplands is very close. The material microscopically examined includes—Graphic Granite and Granophyric Granite (in segregation veins); Biotite Granite, Biotite Hornblende Granite, Biotite Augite Granite; Tonalite (intermediate between Hornblende Biotite Granite and Diorite); Quartz Hornblende Diorite, Quartz Augite Biotite Diorite, Quartz Hypersthene Diorite; Biotite Augite Diorite, Hornblende Diorite, Hypersthene Diorite; Hyperite and Gabbro.

This mass is intrusive into the Lower Old Red Sandstone, which at Lanfine, a little west of this, has yielded *Cephalaspis Lyelli*. The Old Red Sandstone is indurated and often hornfelsed to a varying distance from the margin. The new minerals developed are Augite,

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

Hornblende, Biotite, Magnetite, Tourmaline, Spinel, and possibly Sillimanite; Calcite, Chlorite, and Epidote are often present, but appear to be secondary after some of those mentioned.

Many dykes penetrate the sandstones, and most of these are undoubtedly apophyses of the Granite. They are mostly Diorite Porphyrites or Quartz Diorite Porphyrites, which may contain Biotite, Augite, Hornblende, or Hypersthene. Syenite Porphyries also occur, and occasionally small veins of more acid character, which may be considered coarse-grained Granophyres. In addition to these there are several dykes of Olivine Dolerite and Andesitic Basalt, but these are not known to be genetically connected with the Granite.

III.—Notes on the occurrence of Phosphatic Nodules and Phosphate-bearing Rock in the Upper Carboniferous Limestone (Yoredale) Series of the West Riding of Yorkshire and Westmoreland Border. By John Rhodes, of the Geological Survey.[1]

BY kind permission of the British Association Committee on Carboniferous Zones I am enabled to announce the discovery of phosphatic nodules and of a rock having a phosphatic matrix in the Yoredale rocks of the following localities:—

Phosphatic Nodules: Far Cote Gill, East Slope of Swarth Fell, Westmoreland.

These nodules occur along with ironstone septaria in blue shales which rest on the top siliceous beds of the Underset Limestone. The nodules are confined to the lower 5 feet of the shales, and are more numerous in the lower half than in the upper half.

In the same gill, and resting on the chert of the Little Limestone, there is a layer, 3 inches in thickness, containing phosphatic nodules embedded in a fine clayey matrix. It is sprinkled throughout with glauconite grains and angular chips of quartz, and is overlain by ironstone shales.

At the same horizon as above, but $2\frac{1}{4}$ miles to the south-east, there occurs in a gill that runs from Lambfold Crags to Lunds Church, two miles west of north of Hawes Junction, a layer of rock three inches in thickness, with a phosphatic matrix throughout. This layer, which has a crust of brown iron-ore, is rich in glauconite and quartz grains, and also contains fragments of conodonts, etc.

Phosphatic Nodules: Goodham Gill, East Slope of Swarth Fell, 2 miles north-west of Hawes Junction, Yorkshire.

The phosphatic nodules at this locality occur throughout a limestone which varies in thickness from 3 to 6 inches. This layer is underlain and overlain by shale in more or less rotten condition. The horizon is doubtful, but it appears to be about 170 feet over the Little Limestone. From the upper surface of the top bed of the Crow Limestone, Cartmere Gill, East Baugh Fell, Grisdale,

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

2½ miles west-north-west of Hawes Junction, I have obtained a solitary example of a phosphatic nodule. The phosphatic nodules and phosphatic matrix examined show sponge spicules, but these are for the most part fragmentary; some are of crypto-crystalline silica, some replaced by calcite, whilst the axial canals are often filled with the same phosphatic material as the matrix. The spicules are referred to hexactinellid and to monactinellid sponges.

I am very much indebted to Dr. G. J. Hinde for notes on the sponge remains, and also to Dr. W. Pollard for testing the phosphates.

IV.—Short Notices.—In Sprawozdanie Komisyi fizyograficznej, Cracow, vol. xxxvi, pp. 11, 12, Professor J. L. M. Lomnicki describes a new species of *Elater*, *E. Wisniowskii*, based on a right elytra found between fossil leaves in Miocene clay near Kolomea. The elytra most nearly resembles that of *Elater ferrugatus*, a species now living in the same European region. It is the oldest fossil insect as yet found in Galicia, those described by A. M. Lomnicki, the Professor's father, being of Pleistocene age. The paper is written in Latin, and illustrated by three text-figures.

Bolivian Fossils and Rocks.—In Sir Martin Conway's "The Bolivian Andes" (Harper, 1901) will be found appendices by R. B. Newton on some Devonian Brachiopoda and incertæ sedis, by L. J. Spencer on Bolivian minerals, and by T. G. Bonney on rock specimens collected during the expedition. The author refrains from acknowledging his indebtedness to these writers on his title-page, and as he does not trouble to write a preface to his volume the papers are likely to be overlooked.

REVIEWS.

The Geological Survey of the United Kingdom.

THE Summary of Progress of this institution for 1900 has just been issued, somewhat tardily if we may judge by Sir Archibald Geikie's preface, the date of which (February 28th) coincides with the termination of his long period of public service.

A considerable portion of the volume before us is taken up with a description of the structure and mineral characters of the Highland schists. Reference is made to the mapping of certain "Green beds," which in the area north of the Tay are represented by fine hornblendic schists, usually containing small garnets; and to the characters by which these altered sedimentary rocks can be distinguished from the epidiorites.

In Ireland the volcanic rocks in the Silurian series have received much attention; while in Cornwall and Devon the subdivision of the "Killas," the correlation of the Lower Devonian rocks near Looe, and the various "greenstones" have occupied those engaged in the field.

The Old Red Sandstone has been studied in various localities from Caithness to South Wales. Especially interesting are the observations on the newer granites of the Southern Highlands and

their connection with the Lorne volcanic region, where the volcanic vents are of Lower Old Red Sandstone age. The granites are those of Ben Cruachan, Blackmount, and the Moor of Rannoch.

Work has been carried on in the Coalfields of South Wales and North Staffordshire. Attention has been recalled to the Gower Series near Swansea, Lower Carboniferous strata which lie above the massive Carboniferous Limestone. They had been compared with the Coddon Hill Beds of North Devon by De la Beche, and recent investigation has confirmed the correlation. Moreover, Radiolaria have been identified in the South Wales chert by Dr. G. J. Hinde. A somewhat similar group of strata has been observed along the northern side of the Coal-basin in Carmarthenshire.

Some of the detailed results of the Survey work in the Coal-measures near Swansea are given, and attention is drawn to the positions of the principal seams of coal and to the faults and disturbances by which they are affected.

Comparisons are made between the succession of Coal-measures in North Staffordshire and that in Denbighshire, the stratigraphical divisions being found to be so nearly identical that evidently the same conditions were prevalent in both districts at the close of the Carboniferous Period. A very similar succession, moreover, can be made out on the northern flanks of the Clent Hills between St. Kenelms and Old Hill.

There are notes on the granite of Cornwall, and evidence is given for concluding that not only is there a close connection between the major joints and the grain of the rock, but that this grain is dependent on the internal mineral arrangement of the granite, all three phenomena being closely related. This is noticed in the orientation of the felspars, of which the long axes lie parallel to the cleaving-way joints.

There are short accounts of Triassic and Jurassic strata in the midland counties of England and in Skye. More attention is given to Cretaceous rocks, and comparisons are made between the divisions of the Lower Greensand in West Sussex and in the Isle of Wight. The occurrence of masses of white limestone and chert with Chalk fossils, in a large volcanic vent in the Isle of Arran, is recorded, and further particulars are given of the interesting discovery therein of fragmentary portions of Rhætic and Liassic strata. These researches have not only thrown new light on the former extension of the Secondary strata over the south of Scotland, but they also afford evidence of the Tertiary age of the great series of younger igneous rocks in Arran.

Further information is given on the Tertiary volcanic series in Skye and on dykes in Western Argyllshire.

Reference is made to the overlap of the Bagshot Beds on to the Chalk in the western part of the Hampshire Basin, and attention is called also to the overlap of the London Clay, which in places cuts through the Reading Beds and rests on Chalk. The occurrence is noted of small quantities of nickel and cobalt in the Reading Beds at Cadmore End Common, near High Wycombe.

The Pleistocene deposits, including Glacial drifts, are described in various districts in the southern and midland counties of England, in South Wales, in the Highlands of Scotland, in Skye, and Caithness. Especially interesting is the account of the high-level and other drifts near Macclesfield in Cheshire. The more recent deposits have also received attention. In the petrographical work we note a special account of the remarkable assemblage of eruptive rocks which has been detected in Assynt, and of the metamorphism induced by them on the surrounding dolomites. Thus it is shown that the marbles of Assynt are mainly altered dolomites.

The palæontological work has largely assisted the stratigraphical work, and aid has been given by Mr. R. Kidston in naming the Carboniferous plants of Berwickshire, and by Dr. Traquair in naming the Silurian fishes of Lesmahagow.

The important catalogue of type and figured fossils preserved in the Museum of Practical Geology, commenced in the Summary of Progress for 1899, is continued by the publication of the lists of Pleistocene, Pliocene, and Devonian specimens.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 20th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair.

Dr. Vaughan Cornish, in exhibiting Photographs of Waves and Ripples in Water, Cloud, Sand, and Snow, said that he need only refer to the photographs showing the action of wind upon snow, which were the most recent of the series of pictures which he was exhibiting that evening. He had spent from December to March last Winter studying the snow in the provinces of Quebec, Manitoba, and British Columbia. When the wind blew one saw the processes of wind-erosion and of the accumulation of drifted material proceeding with a rapidity which is not attained when wind acts upon heavier or harder materials. He particularly commended to geologists the study of wind-erosion of snow hardened by pressure and low temperature. The cutting and carving, and the revelation of previously invisible stratification, went on at a surprising rate, and one could see the structures change from form to form under one's very eyes, and thus quickly gain such an insight into the processes of wind-erosion as, in the case of more stubborn rock, could only be obtained by prolonged study. The advantage, moreover, of studying the process in snow was not merely one of time, but consisted partly in the recognition of transitional stages which were so apt to be missed when observations were necessarily intermittent, as was the case with those of erosion of harder rocks.

The following communications were read :—

1. "Notes on the Genus *Lichas*." By Frederick Richard Cowper Reed, Esq., M.A., F.G.S.

The various attempts which have been made to separate this genus into subgeneric groups have not been altogether satisfactory, owing to the difficulty of deciding what are the more important structural features. A natural classification, as opposed to an artificial one, should be based on the structural characters of the head-shield; and the variations in the form and lobation of the glabella in the Lichadidæ (as Beecher has remarked) indicate differences in the relative development of the appendages and organs of the head. The origin and application of the various proposals for classification are considered, and certain synonyms and names of prior application to other organisms are rejected. Next, the characters of the original type-species of the various subgenera are summarized. The second part of the paper contains a critical consideration of the homologies of the furrows and lobes in the glabella of the Lichadidæ. Following Beecher's scheme, the anterior lateral portion of the so-called median or frontal lobe is considered to correspond to the antennulary or true first lobe of the glabella. The so-called 'first' lateral lobes of *Lichas* would correspond to the fused antennary and mandibular lobes, the true second and third lobes of the glabella. The lateral lobes, which are usually termed the 'middle' or 'second' lateral lobes, become homologous with the fourth or first maxillary; and the neck or occipital lobe or ring falls into its right place as the second maxillary lobe. By means of this principle an attempt is made to discover the principal lines of modification along which the evolution of the head-shields of the Lichadidæ has proceeded. In the third part of the paper the Lichadidæ are divided into two great groups: (1) that with a pair of bi-composite lateral lobes to the glabella and a more or less definite fourth pair of lateral lobes; and (2) a group with a pair of tri-composite lateral lobes, through the fusion of the fourth pair with the bi-composite pair of the preceding group. Names are proposed for each group, and also, where necessary, for the eight sections, of subgeneric value, into which each group is subdivided. The paper closes with a list of the British members of the family Lichadidæ, to show their distribution among the groups and sections.

2. "Some Remarks on the Meteorological Conditions of the Pleistocene Epoch." By Dr. Nils Ekholm, Meteorologiska Central-Anstalten, Stockholm. (Communicated by Professor W. W. Watts, M.A., F.G.S.)

The opinion of the author on this subject differs in some important respects from that of Mr. Harmer. He considers the subject under two heads: (1) What are the meteorological conditions necessary and sufficient to produce a permanent ice-sheet such as that of the Great Ice Age? (2) What will be the influence of such glaciation on the meteorological conditions, especially on the cyclones and anticyclones, of the ice-covered land and on its neighbourhood? The snow-line does not correspond with the mean annual isotherm of 32°, for Verchojansk in Siberia is not glaciated, whereas the southern point of Greenland is. The former has a Winter anticyclone, while

the latter is traversed by the central or northern part of cyclones during the whole year. The area of Pleistocene glaciation in America and Europe coincides with the areas now traversed by the most regularly frequented storm-tracks. There seems to have been about the same difference between the mean annual temperatures of Europe and North America in the Great Ice Age as now, and it is generally agreed that a lowering of the present snow-line by 1,000 metres would give rise to a similar Ice Age. The hypothesis that a glaciation of North America would raise the temperature of Europe, and *vice versâ*, seems to the author physically untenable. The positions and movements of anticyclones are not generally ruled by the ground temperature in our latitudes: they are in most cases eddies formed by the air-circulation in general, and in this the greater area and receipt of heat by the Equatorial regions must always be a preponderating factor. The author considers that the influence of the Glacial Period on atmospheric circulation would probably be similar to that of a cold Winter nowadays. The cyclones would be gradually deviated into a more and more southerly track, while an anticyclone would be formed in the north, not, however, a stationary one, but travelling like a cyclone, only more slowly and irregularly. The Summer must have been cold and stormy, with frequent fogs, somewhat like that of Cape Horn or Kerguelen Island at the present day. The author considers that Mr. Harmer underrates the effect of isolation and overrates that of the winds. "The temperature of the Summer only is essential for the phenomenon of glaciation."

3. "On the Origin of certain Concretions in the Lower Coal-measures." By H. B. Stocks, Esq., F.I.C., F.C.S. (Communicated by Professor W. W. Watts, M.A., F.G.S.)

In certain of the Lower Coal-measures of Lancashire and Yorkshire and in the 'hard-bed coal,' peculiar concretions known as 'coal-balls' occur, which have a considerable interest because they contain well-preserved plant-remains. The author's analysis shows that they consist mainly of calcium-carbonate and iron-pyrites, in varying proportions. Carbonate of lime appears to have been introduced by osmosis through the cell-walls; and that it was introduced in small quantity and under exceptional circumstances appears to be proved by the comparative rarity of the concretions and their presence in this seam of coal only. During the decay of the vegetable matter of which coal is formed, in contact probably also with animal matter, some of the organic matter would pass into solution in water, causing the absorption of the oxygen in solution; the result of this is that further decay would take place under anaërobic conditions. This, occurring in water containing sulphates, would give rise to sulphuretted hydrogen and mud blackened by the presence of ferrous sulphide, while carbonates would also be produced. Experiments were tried (1) on the precipitation of carbonate of lime under varying conditions (in presence of organic matter, etc.); (2) on the action of salts of lime and of

iron on wood; and (3) on the action of bacteria on solutions containing calcium-sulphate in solution and ferric oxide in the deposit. In the first series carbonate of lime was deposited in spheres; in the second it was found that iron-salts are preservatives, but lime-salts are not; and in the third, black mud, largely consisting of ferrous sulphide, was produced, while the calcium-sulphate was converted into carbonate. It is considered that these experiments explain the origin of the 'coal-balls.'

II.—December 4th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair.

Professor Bonney, in exhibiting a series of specimens of Smaragdite-Euphotide from the Saasthal, remarked that they illustrated its variations in mineral composition; the pyroxenic constituent being sometimes diallage, sometimes rather acicular hornblende, sometimes glaucophane, but generally smaragdite; the felspathic constituent passing from a rather changed felspar to the so-called saussurite; garnets are sometimes common, white mica occasional: these different kinds pass one into another. The rock also varies greatly in coarseness, and often exhibits a distinctly streaky structure. He described the locality where the rock occurs *in sitû*.

Dr. Vaughan Cornish, in exhibiting photographs of 'Snow Mushrooms' taken by him in January, 1901, at Glacier House, near the summit of the Canadian Pacific Railway in the Selkirk Mountains, west of the Rockies (British Columbia), altitude 4,000 feet, said that the snowfall had been 25 feet measured, then represented by a 5-foot layer upon the ground. It is said that there is not much wind here, and that the snow mostly falls at a temperature near the melting-point. It has the reniform habit in great perfection, and its clinging masses are very beautiful. The most remarkable thing about it is the formation of symmetrical caps, which overhang, by a yard and more, the supporting pedestal. The stumps of the felled trees usually have bases 2 to 4 feet in diameter, which support the whole depth of snow and are frequently of such a height as to produce, with the cap of snow, an almost perfect reproduction of a mushroom. Their almost perfect symmetry was attained, he believed, by gradual growth until the limit of cohesion was reached in all directions. The tree-stumps being almost exactly circular, the complete cap is also circular. These caps are very stable, the great weight of superincumbent snow welding the lower layers into a tenacious mass. Their study has, at least, a suggestive value to geologists.

The following communications were read:—

1. "On a new Genus belonging to the Leperditiadæ, from the Cambrian Shales of Malvern." By Professor Theodore Thomas Groom, M.A., D.Sc., F.G.S.

Forms referred to *Beyrichia* have long been known from the Cambrian beds of Scandinavia, Stockingford, and South Wales; and

the writer has obtained from the lowest part of the Malvern Black Shales a species identical with the Stockingford form, which had been provisionally identified with the Swedish *Beyrichia Angelini*. The characters of these specimens serve to separate the species from those now placed under the genus *Beyrichia*, a conclusion in which Professor T. Rupert Jones concurs. The specimens were obtained from Black Shales at the northern extremity of Chase End Hill, associated with *Acrotreta*, *Agnostus*, *Kutorgina pusilla*, and *Protospongia fenestrata*. The shales are nowhere actually exposed, and can only be reached by excavation. The specimens are frequently crushed and indented. The new genus appears to be most nearly related to those provided with broad lobes, such as *Klœdenia*, *Beyrichia*, *Ctenobolina*, and *Tetradella*. Specimens obtained by Professor Lapworth from the Oldbury Shales below the zone of *Sphærophthalmus alatus* are also referred to the same genus and species. From Linnarsson's description of *Beyrichia Angelini* it would seem that this form may be related to the new genus, but it clearly belongs to a different species.

2. "The Sequence of the Cambrian and Associated Beds of the Malvern Hills." By Professor Theodore Thomas Groom, M.A., D.Sc., F.G.S. With an Appendix on the Brachiopoda by Charles Alfred Matley, Esq., B.Sc., F.G.S.

The series, exclusive of some 600 feet of igneous rocks, may be estimated at between 2,500 and 3,000 feet, and consists of the following members, tabulated in descending order :—

4. The Bronsil Shales, 1,000 feet thick ; grey shales containing *Dictyonema* and many Tremadoc brachiopods and trilobites.
3. The White-leaved Oak Shales ; black shales, including :
   (*b*) The zone of *Peltura scarabæoides*, *Sphærophthalmus alatus*, *Ctenopyge pecten*, *Ct. bisulcata*, *Agnostus trisectus* ; 500 feet.
   (*a*) The zone containing *Kutorgina pusilla*, *Protospongia fenestrata*, a new variety of *Acrotreta*, and a new genus of the Leperditiadæ ; 30 feet.
2. The Hollybush Sandstone, comprising :
   (*b*) Massive Sandstone, probably not less than 1,000 feet thick, and containing *Kutorgina Phillipsi*, *Orthotheca fistula*, *Scolecoderma antiquissima*, and new species of *Hyolithus*.
   (*a*) Flaggy and Shaly Beds, not less than 75 feet thick ; chiefly flaggy and shaly glauconitic sandstones, with *Kutorgina Phillipsi*, *Scolecoderma antiquissima*, *Hyolithus*, etc.
1. The Malvern Quartzite,[1] consisting chiefly of grey quartzites and conglomerates, rarely glauconitic ; probably at least several hundred feet thick ; containing *Kutorgina Phillipsi*, *Hyolithus primævus*, and a new species of *Obolella*.

The last rock, though now separated by faults from the older Malvern Series, contains angular fragments both of Uriconian and Malvernian type. It is correlated with the Wrekin Quartzite and with the lower divisions of the Hartshill Quartzite. The Flaggy and Shaly Beds appear to correspond with the *Olenellus*-beds and the zone of *Paradoxides Groomi* in Shropshire. The bulk of the Hollybush Sandstone probably represents the greater part of the Paradoxidian of other localities, and may in part correspond with the Purley Beds of Nuneaton.

[1] [This was originally termed by the author 'Hollybush Quartzite.']

The lower division of the White-leaved Oak Shales may represent the Swedish zone with *Beyrichia Angelini*, and perhaps the Festiniog Beds of North Wales. It is, however, more probable that it represents the uppermost portion of the Paradoxidian. The greater part of these shales, however, belongs to the zone of *Sphærophthalmus alatus*; but it is possible that other zones, both immediately above and immediately below, may be represented in the district. The middle part of the Bronsil Shales has yielded Asaphids and Olenids in association with *Dictyonema*, and may be correlated with the Tremadoc beds which yield the *Euloma-Niobe* fauna. The author prefers to endorse the Continental view of these rocks, and to group the Tremadoc Series with the Ordovician, with the reservation that the *Dictyonema*-shales of Europe should be regarded as belonging to the Tremadoc, the base-line of the Ordovician being drawn immediately below these shales.

The paper contains an account of the Hyolithidæ and trilobites of these rocks. Three new species of *Hyolithus* are named and described in full, and four in outline, while a revision of Holl's species *H. fistula* is given. Notes are also given, by Mr. Philip Lake and the author, on *Agnostus trisectus*, *Cheirurus Frederici*, and other trilobites, and a name is given to certain cylindrical bodies which appear to be the eggs or excreta of some animal.

In the Appendix on the Cambrian Brachiopoda of the Malvern Hills, after making a few brief remarks as to our present knowledge of these fossils, Mr. C. A. Matley proceeds to describe a new species of *Obolella* and a new variety of *Acrotreta Sabrinæ*. Species of *Lingulella*, *Lingula*, and *Acrotreta* are described, and a revision is given of *Obolella* (?) *Salteri*, *Lingulella Nicholsoni*, *Acrotreta Sabrinæ*, *Linnarssonia Belti*, and *Kutorgina cingulata* vars. *Phillipsi* and *pusilla*.

CORRESPONDENCE.

ADDITIONAL NOTE ON *AMMONITES CALCAR*, ZIETEN.

Sir,—Since writing the note on *Ammonites calcar*, Zieten, that appeared in the Geological Magazine for December, 1899 (pp. 554–558), there has been found belonging to the specimen there described another original label, which it seems desirable to record. This was fastened in the Museum register; not on the page where the specimen was entered, but some two leaves from the place, so that it was discovered quite by accident. Fortunately, when the specimen was registered the register number was written on the label, so that there can be no doubt whatever about the label belonging to this actual specimen. The label bears the following inscription in the handwriting of Dr. Bruckmann, from whom the fossil was obtained: "*Ammonites calcar* Benz; Zieten. Brown Jura ζ; Ornatenthon. Unic [*sic*] of Zieten's collection; *extremely rare*! Gamelshausen in Württemberg. Professor Dr. Kurr told me that he was about to buy the whole of Zieten's collection, only in